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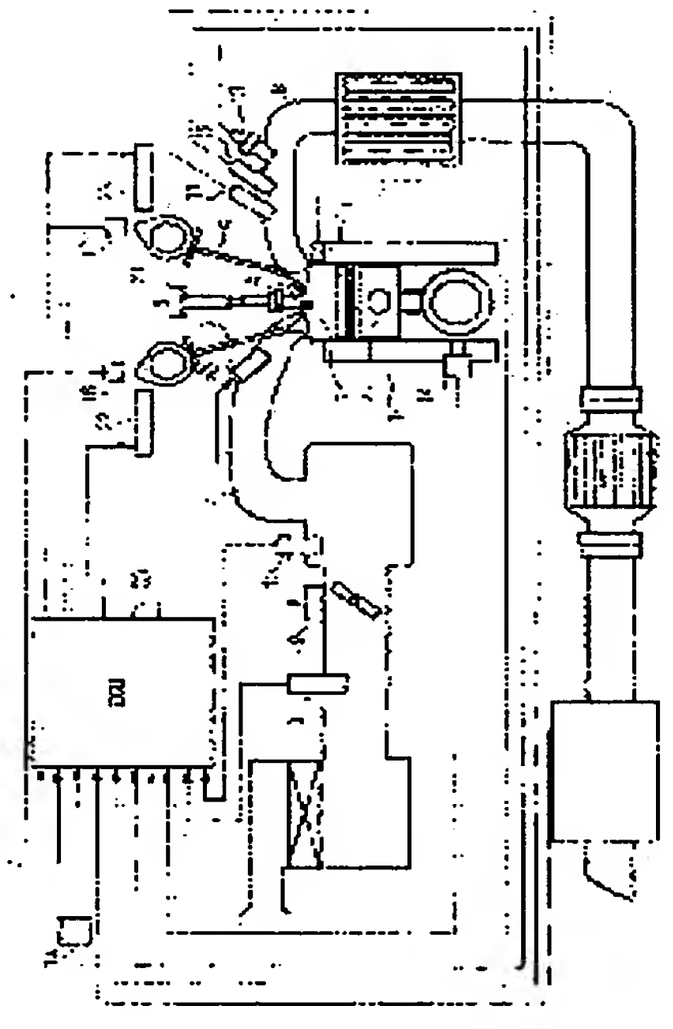
(54) INTERNAL EGR AMOUNT ESTIMATING DEVICE OF INTERNAL COMBUSTION ENGINE

(57)Abstract:

PROBLEM TO BE SOLVED: To precisely estimate an internal EGR amount from the quantity of state in the cylinder of the engine by using a physical equation.

SOLUTION: When an exhaust valve is closed, based on signals from an exhaust temperature sensor 12, an intake pressure sensor 10, and exhaust pressure sensor 11, a cylinder temperature and a cylinder pressure are calculated, the gas constant of exhaust gas according to a combustion air/fuel ratio is calculated, and a cylinder gas amount is calculated. Then, based on signals from a crank angle sensor 14, a water temperature sensor 15, cam angle sensors 16 and 17, and an accelerator opening sensor 18, a blowback gas amount during overlapping in an intake valve opening period and an exhaust valve opening period is calculated. Based on the calculated values of the cylinder gas amount and the blowback gas amount, the internal EGR amount is calculated.



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CLAIMS

[Claim(s)]
[Claim 1]
A means to compute whenever [cylinder internal temperature / at the time of exhaust air bulb clausilium],
A means to compute the cylinder internal pressure at the time of exhaust air bulb clausilium,
A means to compute the gas constant of the exhaust gas presentation according to a combustion air-fuel ratio,
A means to compute the capacity in a cylinder at the time of exhaust air bulb clausilium whenever [said cylinder internal temperature] based on said cylinder internal pressure and said gas constant at least,
It has a means to blow under overlap of an exhaust air bulb open period and an intake valve open period, and to compute capacity,
The amount presumption equipment of internals EGR of the internal combustion engine characterized by the capacity in said cylinder, and said thing [blowing and computing the amount of internals EGR based on capacity].
[Claim 2]
It is a capacity calculation means in a cylinder at the time of said exhaust air bulb clausilium,
A means to compute the cylinder content volume at the time of exhaust air bulb clausilium,
A means to compute whenever [cylinder internal temperature / at the time of said exhaust air bulb clausilium],
A means to compute the cylinder internal pressure at the time of said exhaust air bulb clausilium,
A means to compute the gas constant of the exhaust gas presentation according to said combustion air-fuel ratio,
The amount presumption equipment of internals EGR of the internal combustion engine according to claim 1 characterized by consisting of ****** and computing the capacity in a cylinder at the time of exhaust air bulb clausilium by the physical type based on these calculation values.
[Claim 3]
A cylinder content volume calculation means is the amount presumption equipment of internals EGR of the internal combustion engine according to claim 2 characterized by calculating the cylinder content volume value geometrically decided from the piston location at the time of exhaust air bulb clausilium at the time of said exhaust air bulb clausilium.
[Claim 4]
A cylinder content volume calculation means is the amount presumption equipment of internals EGR of the internal combustion engine according to claim 2 characterized by calculating the cylinder content volume value at the time of exhaust air bulb clausilium according to those variation in the engine which has the device in which the cylinder content volume of an exhaust air bulb clausilium stage and this stage is changed relatively at the time of said exhaust air bulb clausilium.
[Claim 5]
Said gas constant calculation means is the amount presumption equipment of internals EGR of the internal combustion engine of any one publication of claim 1 characterized by asking for the gas constant corresponding to change of an exhaust gas presentation - claim 4 according to target combustion equivalent ratio.
[Claim 6]
It blows during said overlap and is a capacity calculation means,
A means to compute whenever [cylinder internal temperature / at the time of said exhaust air bulb clausilium],

A means to compute the cylinder internal pressure at the time of said exhaust air bulb clausilium,
A means to compute the gas constant corresponding to the exhaust gas presentation change according to said combustion air-fuel ratio,
A means to compute a MAP,
A means to compute the ratio of specific beat corresponding to exhaust gas presentation change,
A means to compute the addition effective area under overlap of an exhaust air bulb open period and an intake valve open period,
A means to compute an engine rotational frequency,
A means to judge the existence of supercharge and a choke,
The amount presumption equipment of internals EGR of the internal combustion engine of any one publication of claim 1 characterized by consisting of ******, blowing under overlap based on these calculation values, and computing capacity - claim 5.
[Claim 7]
Said supercharge and the judgment means of a choke,
Based on cylinder internal pressure, it has a means to compute an inhalation-of-air exhaust-gas-pressure ratio, at the time of said MAP and said exhaust air bulb clausilium,
The amount presumption equipment of internals EGR of the internal combustion engine according to claim 6 characterized by setting it up when said supercharge judging means makes the ratio of specific beat corresponding to said exhaust gas presentation change those with supercharge.
[Claim 8]
It is an addition effective-area calculation means during said overlap,
A means to compute intake valve closing motion timing,
A means to compute exhaust air bulb closing motion timing,
since -- the amount of overlap -- computing
The amount presumption equipment of internals EGR of the internal combustion engine according to claim 6 or 7 characterized by calculating the integrated value of effective area according to this amount of overlap.

[Claim 9]
It is an addition effective-area calculation means during said overlap,
The amount presumption equipment of internals EGR of the internal combustion engine according to claim 6 or 7 characterized by computing addition effective area by integrating with either minimum value of the opening area in an inhalation-of-air valve lift, and the opening area in an exhaust air valve lift.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]
This invention relates to an internal combustion engine's amount (amount of reflux of emission gas) presumption equipment of internals EGR.
[0002]
[Description of the Prior Art]
In order to aim at reduction of NOx (nitrogen oxides) by the combustion-temperature control by the formation of inerts buildup, and fuel consumption reduction by reduction of a pump loss in a jump-spark-ignition type internal combustion engine from the former, using an adjustable valve gear, the amount of overlap of an exhaust air bulb open period and an intake valve open period is expanded, and there is a thing to which the amount of internals EGR is made to increase. In this case, it is desirable to perform control which amends ignition timing, fuel oil consumption, bulb closing motion timing, etc. according to the amount of internals EGR.
[0003]
Moreover, in the patent reference 1, the basic value of the amount of internals EGR is computed from the service conditions (a load, an engine speed, an air-fuel ratio, an EGR rate, depression at engine manifold, etc.) of the engine at the time of overlap nothing, and amending the amount of internals EGR according to the variation of the service condition at the time of overlap is indicated.
[0004]
[Patent reference 1]
JP,2001-221105,A
[0005]
[Problem(s) to be Solved by the Invention]
However, it was difficult to presume the amount of internals EGR uniquely with the amount of overlap because operational status changes and combination, such as a load, an engine speed, a combustion air-fuel ratio, and a depression at engine manifold, changes.
Moreover, the patent reference 1 was not enough as the precision of the amount of internals EGR computed by change of each parameter, when amending the amount of internals EGR from the variation of a service condition.
[0006]
It is made in order that this invention may solve the above-mentioned problem, and it aims at presuming the amount of internals EGR with a sufficient precision according to an engine's service condition.
[0007]
[Means for Solving the Problem]
Therefore, in this invention, whenever [cylinder internal temperature / at the time of exhaust air bulb clausilium], the cylinder internal pressure at the time of exhaust air bulb clausilium and the gas constant of the exhaust gas presentation according to a combustion air-fuel ratio are computed respectively, and the capacity in a cylinder at the time of exhaust air bulb clausilium is computed based on these at least. And it blows under overlap of an exhaust air bulb open period and an intake valve open period, and capacity is computed. And it blows with the capacity in a cylinder and the amount of internals EGR is computed based on capacity.
[0008]
[Effect of the Invention]

According to this invention, it is not concerned with a service condition but the amount of internals EGR can be presumed with a sufficient precision based on the quantity of state inside the cylinder after a burn out (gas constant of temperature, a pressure, and exhaust gas).
[0009]
[Embodiment of the Invention]
Hereafter, the operation gestalt of this invention is explained based on a drawing.
Drawing 1 is system configuration drawing of an internal combustion engine's amount presumption equipment of internals EGR.
The combustion chamber 3 formed by the piston 2 of each cylinder of an engine 1 is equipped with the intake valve 5 and the exhaust air bulb 6 so that an ignition plug 4 may be surrounded. The lift property (closing motion stage) of an intake valve 5 and the exhaust air bulb 6 is changing the phase of the cam to a cam shaft by the adjustable valve train solenoids 22 and 23 prepared in the inspired air flow path and the exhaust side, and control of valve timing is possible for it.
[0010]
The electronics control throttle valve 19 is formed in the inhalation-of-air path 7, and, thereby, inhalation new air volume is controlled. supply of a fuel is made by the injector 20 formed in the inhalation-of-air path 7 for every cylinder (or each combustion chamber 3 is attended directly -- making). Gaseous mixture is lit by the ignition plug 4 in a combustion chamber 3, and it burns, and is discharged to a flueway 8.
Here, actuation of the electronics control throttle valve 19, an injector 20, an ignition plug 4 (ignition coil 21 with built-in PAWATORA), and the adjustable valve train solenoids 22 and 23 is controlled by the engine control unit (ECU) 30.
[0011]
The signal from various sensors is inputted into ECU30 for these control.
The crank angle sensor 14 outputs a crank angle signal synchronizing with an engine revolution, and, thereby, can detect an engine speed with a crank angle location. And the cam angle sensors 16 and 17 can detect the cam angle of an intake valve 5 and the exhaust air bulb 6, and, thereby, can detect the operating state of the adjustable valve train solenoids 22 and 23.
[0012]
and At the inhalation-of-air path 7 inhalation new air volume The air flow meter 9 to detect, the MAP sensor 10 which detects a MAP on electronics control throttle-valve 19 lower stream of a river, the exhaust-gas-pressure sensor 11 which detects exhaust gas pressure in a flueway 7, the exhaust-gas-temperature sensor 12 which detects an exhaust-gas temperature in a flueway 8, and the amount of oxygen contained during exhaust air in a flueway 8 The output signal of O2 sensor (oxygen sensor) 13 to detect, the coolant temperature sensor 15 which detects the circulating water temperature of an engine 1, and the accelerator opening sensor 18 which detects an accelerator opening is also inputted into ECU30, and these conditions can be detected.
[0013]
Next, presumption of the amount of internals EGR which ECU30 performs, and the rate of internal EGR is explained below. Drawing 2 - drawing 7 are control block diagrams, drawing 8 - drawing 16 </A> are control flow charts, and drawing 17 - drawing 2222 are tables which calculate each value.
Calculation of the rate MRESFR of internal EGR is explained using the control block diagram of the rate calculation means of internal EGR of drawing 2 , and the rate MRESFR calculation flow of internal EGR of drawing 8 .
[0014]
As for the inhalation new-air-volume calculation means shown in drawing 2 , the target combustion equivalent ratio TFBYA and the amount calculation means of internals EGR compute the amount MRES of internals EGR, respectively, as for the inhalation new air volume (the amount of new dispositions) MACYL, and a target combustion equivalent ratio calculation means, and the rate calculation means of internal EGR computes the rate MRESFR of internal EGR based on these calculation values.
At step 1 of drawing 8 , the inhalation new air volume MACYL per cylinder is computed based on the inhalation new air volume measured by the air flow meter 9.
[0015]
At step 2, the target combustion equivalent ratio TFBYA decided according to the engine speed detected based on the signal of the crank angle sensor 14, the accelerator opening detected based on the signal of the accelerator opening sensor 18, and the circulating water temperature detected based on the signal of a coolant temperature sensor 15 is computed.

In addition, if theoretical air fuel ratio is set to 14.7, the target combustion equivalent ratio TFBYA is expressed by the degree type from a target combustion air-fuel ratio, and when a target combustion air-fuel ratio is SUTOIKI, it will be set to 1.

[0016]

TFBYA=14.7-/target combustion air-fuel ratio ... (1)

At step 3, the amount MRES of internals EGR per cylinder is computed according to the flow chart of drawing 9 mentioned later.

At step 4, the rate MRESFR of internal EGR (the amount of internals EGR to the total capacity per cylinder comparatively) is computed by the degree type, and processing is ended.

[0017]

MRESFR=MRES/{MRES+MACYLx (1+TFBYA/14.7)} ... (2)

Here, calculation of the amount MRES of internals EGR of step 3 is explained using the control block diagram of the amount calculation means of internals EGR of drawing 3 , and the amount calculation flow of internals EGR of drawing 9 .

[0018]

The capacity calculation means in a cylinder is blown during the overlap (it is indicated in drawing as "O/L") of capacity MRESCYL in a cylinder, an intake valve 5, and the exhaust air bulb 6 at the time of the exhaust air bulb clausilium shown in drawing 3 (it is indicated in drawing as "the time of EVC"), a capacity calculation means is blown, capacity MRESOL is computed, respectively, and the amount calculation means of internals EGR computes the amount MRES of internals EGR based on these calculation values.

[0019]

At step 5 of drawing 9 , capacity MRESCYL in a cylinder is computed according to the flow chart of drawing 10 mentioned later at the time of the exhaust air bulb clausilium which is the capacity which remains inside a cylinder at the time of exhaust air bulb clausilium.

At step 6, according to the flow chart of drawing 11 mentioned later, it blows during the overlap which is the capacity blown from an exhaust side to an inspired air flow path during overlap, and capacity MRESOL is computed.

[0020]

At step 7, it blows during capacity MRESCYL in a cylinder, and overlap at the time of exhaust air bulb clausilium, capacity MRESOL is added, and the amount MRES of internals EGR is computed by the degree type.

MRES=MRESCYL+MRESOL ... (3)

Here, calculation of capacity MRESCYL in a cylinder is explained to be the control block diagram of the capacity calculation means in a cylinder using the capacity MRESCYL calculation flow in a cylinder at the time of the exhaust air bulb clausilium of drawing 10 at the time of the exhaust air bulb clausilium of drawing 4 at the time of the exhaust air bulb clausilium of step 5.

[0021]

The target combustion equivalent ratio calculation means shown in drawing 4 computes the target combustion equivalent ratio TFBYA of exhaust gas, and an exhaust gas gas constant calculation means computes gas constant REX based on this value. In a calculation means, a pressure calculation means computes [a cylinder content volume calculation means / whenever / cylinder internal temperature] the cylinder internal pressure PEVC whenever [cylinder internal temperature], respectively at the time of TEVC and exhaust air bulb clausilium at the time of the cylinder content volume VEVC and exhaust air bulb clausilium at the time of exhaust air bulb clausilium. And based on these calculation values, the capacity calculation means in a cylinder computes capacity MRESCYL in a cylinder at the time of exhaust air bulb clausilium.

[0022]

At step 8 of drawing 10 , it asks for the cylinder content volume VEVC from the table shown in drawing 17 at the time of exhaust air bulb clausilium. Drawing 17 is a cylinder content volume VEVC calculation table at the time of exhaust air bulb clausilium, an axis of abscissa shows the exhaust air bulb closing motion timing variation VTCNOWE, and the axis of ordinate shows the cylinder content volume VEVC at the time of exhaust air bulb clausilium.

Here, in the engine which has the device in which an exhaust air bulb clausilium stage is changed, it asks for the cylinder content volume VEVC from a table according to the exhaust air bulb closing motion timing variation VTCNOWE detected based on the signal of the cam angle sensor 17 of an exhaust side at the time of the exhaust air bulb clausilium shown in drawing 17 .

[0023]
In addition, in the engine which has the device in which a compression ratio is changed, it asks for the cylinder content volume VEVC from a table at the time of the exhaust air bulb clausilium according to the variation of a compression ratio.
Moreover, in the engine which has the device which makes adjustable simultaneously an exhaust air bulb clausilium stage and a compression ratio, it asks for the cylinder content volume VEVC from a table at the time of the exhaust air bulb clausilium according to an exhaust air bulb clausilium stage and compression ratio variation.
[0024]
At step 9 of drawing 10 , gas constant REX of exhaust gas according to the target combustion equivalent ratio TFBYA is calculated from the table shown in drawing 18 . Drawing 18 is an exhaust gas gas constant REX calculation table, an axis of abscissa shows the target combustion equivalent ratio TFBYA, and the axis of ordinate shows gas constant REX of exhaust gas. In addition, the dotted line in drawing 18 shows SUTOIKI.
At step 10, TEVC is presumed whenever [cylinder internal temperature] based on the exhaust-gas temperature detected based on the signal of the exhaust-gas-temperature sensor 12 at the time of exhaust air bulb clausilium. In addition, at the time of exhaust air bulb clausilium, whenever [cylinder internal temperature], since TEVC changes with the heating values according to the fuel oil consumption of an injector 20, it may be calculated from the table using such a property.
[0025]
At step 11, the cylinder internal pressure PEVC is presumed based on the exhaust gas pressure detected based on the signal of the exhaust-gas-pressure sensor 11 at the time of exhaust air bulb clausilium. In addition, at the time of exhaust air bulb clausilium, since the cylinder internal pressure PEVC is decided by the gaseous mixture product and tubing internal resistance of an exhaust air system, you may ask for it from the table according to a gaseous mixture product flow rate.
At step 12, capacity MRESCYL in a cylinder is computed by the degree type from the calculation value of the cylinder internal pressure PEVC whenever [cylinder internal temperature] at the time of the exhaust air bulb clausilium which remains inside a cylinder at the time of exhaust air bulb clausilium at the time of TEVC and exhaust air bulb clausilium at the time of the cylinder content volume VEVC, exhaust gas gas constant REX, and exhaust air bulb clausilium at the time of the exhaust air bulb clausilium computed in step 8 - step 11.
[0026]
MRESCYL=(PEVCxVEVC)/(REXxTEVC) ... (4)
Here, it blows during the overlap of drawing 5 , and blows during the control block diagram of capacity calculation, and the overlap of drawing 11 , and calculation of capacity MRESOL blown from an exhaust side to an inspired air flow path during the overlap of step 6 of drawing 9 is explained using a capacity MRESOL calculation flow.
[0027]
The closing motion timing variation calculation means of the exhaust air bulb and intake valve which are shown in drawing 5 computes the overlap variation VTCOL from the closing motion timing variation VTCNOW and VTCNOWE of an intake valve and an exhaust air bulb, and an addition effective-area calculation means computes the addition effective area ASUMOL during overlap based on this calculation value. A target combustion equivalent ratio calculation means computes equivalent ratio TFBYA, and an exhaust gas gas constant calculation means computes gas constant REX based on this calculation value. And based on these calculation values, and an engine-speed calculation means, an exhaust gas ratio-of-specific-beat calculation means and each calculation value according whenever [cylinder internal temperature] to a cylinder internal pressure calculation means, a MAP calculation means, and a choke supercharge judging calculation means the time of a calculation means and exhaust air bulb clausilium the time of exhaust air bulb clausilium, it blows during overlap, and a capacity calculation means is blown and computes capacity MRESOL.
[0028]
At step 13 of drawing 11 , the overlap variation VTCOL is computed by the degree type from the intake valve closing motion timing variation VTCNOW detected based on the signal of the cam angle sensor 16 which detects the phase of an inspired air flow path cam, and the exhaust air bulb closing motion timing variation VTCNOWE detected based on the signal of the cam angle sensor 17 which detects the phase of an exhaust side cam.

[0029]
VTCOL=VTCNOW+VTCNOWE ... (5)
At step 14, it asks for the addition effective area ASUMOL under overlap from the table shown in drawing 19 R> 9 according to the overlap variation VTCOL computed by (5) formulas. Drawing 19 is a table which computes the addition effective area under overlap, an axis of abscissa shows the overlap variation VTCOL, and the axis of ordinate shows the addition effective area ASUMOL under overlap. If the overlap variation VTCOL becomes large, the addition effective area ASUMOL will become large.
[0030]
Here, drawing 20 is the explanatory view of the addition effective area ASUMOL under overlap, and, as for the axis of abscissa, the axis of ordinate shows each opening area of an intake valve 5 and the exhaust air bulb 6 whenever [crank angle]. And effective opening area at a certain event under overlap is made into the smaller one among exhaust air bulb opening area and intake valve opening area. That is, the addition effective area ASUMOL during the whole term under overlap is shown as an integral value (slash section in drawing) of the period which the intake valve 5 and the exhaust air bulb 6 are opening.
[0031]
Thus, by computing the addition effective area ASUMOL during overlap, false [of the amount of overlap of an intake valve 5 and the exhaust air bulb 6] can be carried out with one orifice (runoff hole), and the flow rate which passes this orifice from the condition of an exhaust air system and the condition of an inhalation-of-air system is computed in simple.
At step 15 of drawing 11 , engine-speed NRPM is computed based on the signal of the crank angle sensor 14.
[0032]
At step 16, the exhaust gas ratio of specific beat SHEATR is computed from the map shown in drawing 21 . This control configuration is shown in drawing 6 .
As for the target combustion equivalent ratio calculation means shown in drawing 6 , a calculation means computes [whenever / cylinder internal temperature] TEVC whenever [cylinder internal temperature], respectively at the time of the target combustion equivalent ratio TFBYA and exhaust air bulb clausilium, and an exhaust gas ratio-of-specific-beat calculation means computes the exhaust gas ratio of specific beat SHEATR based on these calculation values.
[0033]
Drawing 21 is an exhaust gas ratio-of-specific-beat calculation map, an axis of abscissa shows the target combustion equivalent ratio TFBYA, and the axis of ordinate shows the exhaust gas ratio of specific beat SHEATR. In addition, if the exhaust gas ratio of specific beat SHEATR becomes small and is on the rich or Lean side when the dotted line in drawing shows the location of SUTOIKI and the target combustion equivalent ratio TFBYA is near SUTOIKI, the ratio of specific beat SHEATR will become large. And a thick wire arrow head shows the case where TEVC changes whenever [cylinder internal temperature / at the time of exhaust air bulb clausilium]. Here, according to TEVC, it asks for the exhaust gas ratio of specific beat SHEATR whenever [cylinder internal temperature] at the time of the exhaust air bulb clausilium computed at step 10 of the target combustion equivalent ratio TFBYA computed at step 2 of drawing 8 , and drawing 10 .
[0034]
At step 17, the control block diagram of a supercharge and a choke judging means of drawing 7 to mention later, and supercharge judging TBCRG and the choke judging CHOKE flow of drawing 12 perform the supercharge judging TBCRG and the choke judging CHOKE.
At step 18, whether the supercharge judging flag TBCRG in step 17 being 0 and a supercharge condition are judged. When the supercharge judging flag TBCRG is 0, it progresses to step 19, and when the supercharge judging flag TBCRG is not 0, it progresses to step 22.
[0035]
At step 19, whether the choke judging flag CHOKE in step 17 being 0 and a choke condition are judged. When the choke judging flag CHOKE is 0, average **** return quantity-of-gas-flow MRESOLtmp under having no supercharge and overlap at the time of choke nothing is computed from the flow of drawing 13 which progresses to step 20 and is mentioned later.
[0036]
On the other hand, at step 19, when the choke judging flag CHOKE in step 17 is not 0, from the flow of drawing 14 which progresses to step 21 and is mentioned later, it blows under having no supercharge and overlap at the time of those with a choke, and quantity-of-gas-flow MRESOLtmp is computed.

Moreover, at step 18, the supercharge judging flag TBCRG in step 17 is 1, i.e., a supercharge condition, and average **** return quantity-of-gas-flow MRESOLtmp under overlap at the time of those with supercharge and choke nothing is computed from the flow of drawing 15 which progresses to step 23 and is later mentioned when the choke judging flag CHOKE is 0 at step 22.
[0037]
On the other hand, at step 22, when the choke judging flag CHOKE in step 17 is 1, from the flow of drawing 16 which progresses to step 24 and is mentioned later, it blows at the time of those with those with supercharge, and a choke, and quantity-of-gas-flow MRESOLtmp is computed.
It progresses to step 25, after blowing at steps 20, 21, 23, and 24 and computing quantity-of-gas-flow MRESOLtmp.
[0038]
In blowing and integrating the addition effective area ASUMOL in quantity-of-gas-flow MRESOLtmp and an overlap period at step 25, according to the condition of the existence of supercharge, and the existence of a choke, it blows under overlap and capacity MRESOL is computed by the degree type.
MRESOL=(MRESOLtmpxASUMOLx60)/(NRPMx360) ... (7)
Here, the supercharge and choke judging in step 17 are explained using the control block diagram of the supercharge and choke judging means of drawing 7 , and supercharge judging TBCRG and the choke judging CHOKE flow of drawing 12 .
[0039]
Based on each calculation value of a cylinder internal pressure calculation means and a MAP calculation means, supercharge and a choke judging means perform the supercharge judging TBCRG and the choke judging CHOKE at the time of an exhaust gas ratio-of-specific-beat calculation means and exhaust air bulb clausilium as shown in drawing 7 .
At step 26 of drawing 12 , the ratio PINBYEX with the cylinder internal pressure PEVC, i.e., an inhalation-of-air exhaust-gas-pressure ratio, is computed by the degree type at the time of the exhaust air bulb clausilium computed at step 11 of MAP PIN detected based on the signal of the MAP sensor 10, and drawing 10 .
[0040]
PINBYEX=PIN/PEVC ... (8)
At step 27, whether the inhalation-of-air exhaust-gas-pressure ratio's PINBYEX being one or less and a supercharge condition are judged.
When the inhalation-of-air exhaust-gas-pressure ratio PINBYEX is one or less (i.e., when you have no supercharge), it progresses to step 28, and supercharge judging flag TBCRG=0 is set as 0, and it progresses to step 31.
[0041]
the air searched for on the other hand from the table showing the exhaust gas ratio of specific beat SHEATR which it progressed to step 29 in with supercharge, set the supercharge judging flag TBCRG as 1, progressed to step 30, and was computed at step 16 of drawing 1111 in drawing 22 when the inhalation-of-air exhaust-gas-pressure ratio PINBYEX was larger than 1, and the gaseous mixture of a fuel -- it considers as the ratio of specific beat MIXAIRSHR.
[0042]
drawing 22 -- gaseous mixture -- a ratio-of-specific-beat MIXAIRSHR calculation table -- it is -- an axis of abscissa -- the target combustion equivalent ratio TFBYA and an axis of ordinate -- gaseous mixture -- the ratio of specific beat MIXAIRSHR is shown. In addition, the dotted line in drawing shows SUTOIKI, and the ratio of specific beat MIXAIRSHR is large at the time of the Lean side, and it becomes small at the time of a rich side. and the gaseous mixture corresponding to the target combustion equivalent ratio TFBYA computed at step 2 of drawing 2 -- it asks for the ratio of specific beat MIXAIRSHR from a table.
[0043]
and the step 30 -- setting -- the exhaust gas ratio of specific beat SHEATR -- gaseous mixture -- the ratio of specific beat of the gas which passes an orifice by transposing to the ratio of specific beat MIXAIRSHR when the gas flow under overlap at the time of supercharge of a turbo charger, inertia supercharging, etc. goes to an exhaust air system from an inhalation-of-air system (it blows) -- the inhalation of air from the ratio of specific beat of exhaust gas -- by changing into the ratio of specific beat of gaseous mixture, the capacity to blow is presumed with a sufficient precision and the amount of internals EGR is computed with a sufficient precision.
[0044]

At step 31, choke judging threshold SLCHOKEL of min and max and SLCHOKEH are computed by the degree type based on the exhaust gas ratio of specific beat SHEATR computed at step 16 or step 30.
SLCHOKEL= {2/(SHEATR+1)} ^ {SHEATR/(SHEATR-1)} ... (9a)
SLCHOKEH= {2/(SHEATR+1)} ^ {-SHEATR/(SHEATR-1)} ... (9b)
This choke judging threshold SLCHOKEL and SLCHOKEH are computing the threshold value which carries out a choke.
[0045]
Moreover, in step 31, on a control configuration, when power count is difficult, beforehand, (9a) and the count result of a formula (9b) are memorized as a minimum choke judging threshold SLCHOKEL table and a maximum choke judging threshold SLCHOKEH table, and may be searched for according to the exhaust gas ratio of specific beat SHEATR.
At step 32, the inhalation-of-air exhaust-gas-pressure ratio PINBYEX computed at step 26 is more than minimum choke judging threshold SLCHOKEL, and whether it being in within the limits below maximum choke judging threshold SLCHOKEH and a choke condition are judged.
[0046]
When the inhalation-of-air exhaust-gas-pressure ratio PINBYEX is in within the limits (i.e., when it judges that he has no choke), it progresses to step 33 and the choke judging flag CHOKE is set as 0.
On the other hand, when there is no inhalation-of-air exhaust-gas-pressure ratio PINBYEX in within the limits (i.e., when it is judged as those with a choke), it progresses to step 34 and the choke judging flag CHOKE is set as 1.
[0047]
Moreover, step 20 of drawing 11 blows, it blows during overlap at the time of having-no supercharge of drawing 1313 , and choke nothing, and calculation of quantity-of-gas-flow MRESOLtmp is explained using a quantity-of-gas-flow calculation flow.
At step 35, the quantity-of-gas-flow formula consistency term MRSOLD is computed by the degree type based on TEVC whenever [cylinder internal temperature / at the time of gas constant REX of the exhaust gas computed at step 9 of drawing 10 , and the exhaust air bulb clausilium computed at step 10].
[0048]
MRSOLD=SQRT {1/(REXxTEVC)} ... (10)
Here, SQRT is a multiplier about temperature and a gas constant. In addition, on a control configuration, when calculation of the quantity-of-gas-flow formula consistency term MRSOLD is difficult, beforehand, the count result of (10) types is memorized as a map, and you may ask according to TEVC whenever [exhaust gas gas constant REX and cylinder internal temperature].
[0049]
At step 36, the quantity-of-gas-flow formula pressure-differential term MRSOLP is computed by the degree type based on the exhaust gas ratio of specific beat SHEATR computed at step 16 of drawing 11 , and the inhalation-of-air exhaust-gas-pressure ratio PINBYEX computed at step 26 of drawing 12 .
MRSOLP=SQRT [SHEATR/(SHEATR-1) x {PINBYEX^(2-/SHEATR)-PINBYEX^ (SHEATR+1) (/SHEATR)}] ... (11)
At step 37, based on the quantity-of-gas-flow formula consistency term MRSOLD and the quantity-of-gas-flow formula pressure-differential term MRSOLP which were computed at the cylinder internal pressure PEVC, step 35 of drawing 13 , and step 36 at the time of the exhaust air bulb clausilium computed at step 11 of drawing 10 , it blows under overlap at the time of supercharge-less - choke nothing, and a flow rate MRESOLtmp is computed by the degree type.
[0050]
MRESOLtmp=1.4xPEVCxMRSOLDxMRSOLP ... (12)
Moreover, step 21 blows, it blows at the time of having no supercharge of drawing 14 , and those with a choke, and quantity-of-gas-flow MRESOLtmp is explained using a quantity-of-gas-flow calculation flow.
[0051]
At step 38, the quantity-of-gas-flow formula consistency term MRSOLD is computed from the above-mentioned (10) types as well as step 35 of drawing 13 .
At step 39, the pressure-differential term MRSOLPC is searched for by the degree type based on the exhaust gas ratio of specific beat SHEATR computed at step 16 of drawing 11 at the time of a quantity-of-gas-flow formula choke.
[0052]
MRSOLPC=SQRT [SHEATRx{2/(SHEATR+1)}^ {(SHEATR+1) /(SHEATR-1)}] ... (13)

In addition, on a control configuration, when power count is difficult, beforehand, the count result of (13) types is memorized as a pressure-differential term MRSOLPC map at the time of a quantity-of-gas-flow formula choke, and may be searched for according to the exhaust gas ratio of specific beat SHEATR.
[0053]
At the time of the choke computed at the quantity-of-gas-flow formula consistency term MRSOLD computed at step 38 of the cylinder internal pressure PEVC and drawing 14 at the time of the exhaust air bulb clausilium computed at step 11 of drawing 10 , and step 39, based on the pressure-differential term MRSOLPC, it blows during the overlap at the time of those with supercharge-less - choke, and a flow rate MRESOLtmp is computed by the degree type at step 40.
[0054]
MRESOLtmp=PEVCxMRSOLDxMRSOLPC ... (14)
Moreover, it blows at the time of those with supercharge, and choke [of drawing 15] nothing, and calculation of average **** return quantity-of-gas-flow MRESOLtmp under overlap of step 23 is explained using a quantity-of-gas-flow calculation flow.
[0055]
At step 41, the pressure-differential term MRSOLPT is searched for by the degree type based on the exhaust gas ratio of specific beat SHEATR computed at step 30 of drawing 12 , and the inhalation-of-air exhaust-gas-pressure ratio PINBYEX computed at step 26 at the time of quantity-of-gas-flow formula supercharge.
MRSOLPT=SQRT [SHEATR/(SHEATR-1) x {PINBYEX^(-2-/SHEATR)-PINBYEX^ (-(SHEATR+1)/SHEATR)}] ... (15)
In addition, constitutionally, when [of control] power count is difficult, beforehand, the count result of (15) types is memorized as a pressure-differential term MRSOLPT map at the time of quantity-of-gas-flow formula supercharge, and may be searched for according to the exhaust gas ratio of specific beat SHEATR and the inhalation-of-air exhaust-gas-pressure ratio PINBYEX.
[0056]
At the time of MAP PIN detected based on the signal of the MAP sensor 10, and the supercharge computed at step 41, based on the pressure-differential term MRSOLPT, it blows during overlap at the time of those with supercharge, and choke nothing, and quantity-of-gas-flow MRESOLtmp is computed by the degree type at step 42.
MRESOLtmp=-0.152xPINxMRSOLPT ... (16)
Here, it blows, and quantity-of-gas-flow MRESOLtmp can express the quantity of gas flow which blows from an inhalation-of-air system to an exhaust air system during overlap with a negative value being shown, and reduces the amount of internals EGR by it based on this.
[0057]
Moreover, step 24 blows, it blows during overlap at the time of those with supercharge and those with a choke of drawing 16 , and calculation of quantity-of-gas-flow MRESOLtmp is explained using a quantity-of-gas-flow calculation flow.
At step 43, the pressure-differential term MRSOLPC is searched for from (13) types or a map as well as step 39 of drawing 14 at the time of a quantity-of-gas-flow formula choke.
[0058]
At the time of MAP PIN and a quantity-of-gas-flow formula choke, based on the pressure-differential term MRSOLPC, it blows during the overlap at the time of those with supercharge, and those with a choke, and quantity-of-gas-flow MRESOLtmp is computed by the degree type at step 44.
MRESOLtmp=-0.108xPINxMRSOLPC ... (17)
Here, it blows, and quantity-of-gas-flow MRESOLtmp can express the quantity of gas flow which blows from an inspired air flow path to an exhaust side during overlap with a negative value being shown, and will reduce the amount of internals EGR by it.
[0059]
Here, at steps 20, 21, 23, and 24, according to the condition of the existence of supercharge, and the existence of a choke, it blows and quantity-of-gas-flow MRESOLtmp is computed. And after blowing during overlap at the above-mentioned step 25 and computing capacity MRESOL, it progresses to step 7 from step 6 of drawing 9 , and the amount MRES of internals EGR is computed at the above-mentioned step 7. And it progresses to step 4 from step 3 of drawing 8 , the above-mentioned rate MRESFR of internal EGR is computed, and processing is ended.
[0060]
A means to compute TEVC whenever [cylinder internal temperature / at the time of exhaust air bulb

clausilium] according to this operation gestalt (step 10), A means to compute the cylinder internal pressure PEVC at the time of exhaust air bulb clausilium (step 11), A means to compute gas constant REX of an exhaust gas presentation according to a combustion air-fuel ratio (step 9), A means to compute capacity MRESCYL in a cylinder at the time of exhaust air bulb clausilium based on TEVC, said cylinder internal pressure PEVC, and said gas constant REX whenever [said cylinder internal temperature] at least (step 12), It has a means (step 25) to blow under overlap of an exhaust air bulb open period and an intake valve open period, and to compute capacity MRESOL, and blows with capacity MRESCYL in a cylinder, and the amount MRES of internals EGR is computed based on capacity MRESOL (step 7). For this reason, based on the quantity of state inside the cylinder after a burn out (temperature TEVC, pressure PEVC, and gas constant REX), the amount MRES of internals EGR is computable from a physical formula. And it can respond to the consistency change by temperature and pressure variation, and the consistency change by change of the gas constant accompanying combustion air-fuel ratio change, and is not concerned with a service condition, but the amount MRES of internals EGR can be presumed with a sufficient precision. Since the quantity of state inside a cylinder changes every moment and the amount MRES of internals EGR is computable in transient operational status especially based on the changing quantity of state, the presumed precision of the amount MRES of internals EGR at the time of transient operation can be improved. And ignition timing, fuel oil consumption, bulb closing motion timing (the amount of overlap), etc. are appropriately controllable by presuming the amount MRES of internals EGR with a sufficient precision. Furthermore, since the amount MRES of internals EGR is computed based on a physical formula (three formulas) and each control value is determined based on this value MRES according to each parameter even if it is control construction containing a multi-dimension parameter, it can build easily.

[0061]

Moreover, according to this operation gestalt, it is constituted including a means (step 8) to compute the cylinder content volume VEVC at the time of exhaust air bulb clausilium further, and capacity MRESCYL in a cylinder at the time of exhaust air bulb clausilium is computed by the physical formula (four formulas) based on these calculation values. For this reason, in consideration of the cylinder content volume VEVC at the time of exhaust air bulb clausilium, the amount MRES of internals EGR is computable from a physical formula (three formulas) based on the quantity of state inside the cylinder after a burn out (volume VEVC, temperature TEVC, pressure PEVC, and gas constant REX). Also in this case, it can respond to the consistency change by temperature and pressure variation, and the consistency change by change of the gas constant accompanying combustion air-fuel ratio change, and is not concerned with a service condition, but the amount MRES of internals EGR can be presumed with a sufficient precision. Moreover, even if it is control construction containing a multi-dimension parameter, in order to compute the amount MRES of internals EGR based on a physical formula (three formulas) according to each parameter, it can build easily and adaptation becomes easy.

[0062]

Moreover, according to this operation gestalt, a cylinder content volume calculation means (step 8) calculates the cylinder content volume value VEVC geometrically decided from the piston location at the time of exhaust air bulb clausilium at the time of exhaust air bulb clausilium. For this reason, the cylinder content volume VEVC at the time of exhaust air bulb clausilium can be computed appropriately, and the more exact amount MRES of internals EGR can be calculated.

Moreover, according to this operation gestalt, a cylinder content volume calculation means (step 8) calculates the cylinder content volume value VEVC at the time of exhaust air bulb clausilium according to the variation in the engine which has the device in which the cylinder content volume of an exhaust air bulb clausilium stage and this stage is changed relatively at the time of exhaust air bulb clausilium. For this reason, even if it is the engine which has the device (adjustable bulb closing motion timing, adjustable compression ratio) in which the cylinder content volume VEVC changes at the time of exhaust air bulb clausilium, it can ask for the cylinder content volume VEVC easily, and the more exact amount MRES of internals EGR can be computed. And since each value is decided geometrically, it can compute easily and can develop efficiently by losing the need by system operation of making it suiting.

[0063]

Moreover, according to this operation gestalt, a gas constant calculation means (step 9) calculates gas constant REX corresponding to change of an exhaust gas presentation according to the target combustion equivalent ratio TFBYA (drawing 18). For this reason, when there is consistency change accompanying the exhaust gas presentation change according to the target combustion equivalent ratio TFBYA (i.e., also when there is a change in the target combustion equivalent ratio TFBYA after a change in a full admission

operation region after Lean operation and start up), the amount MRES of internals EGR can be presumed with a sufficient precision. And gas constant REX can be computed from the reaction formula by a fuel presentation and air presentation, and can be efficiently developed by losing the need by system operation of making it suiting.

[0064]

According to this operation gestalt, it blows during overlap. Moreover, a capacity calculation means (step 25) A means to compute TEVC whenever [cylinder internal temperature / at the time of exhaust air bulb clausilium] (step 10), A means to compute the cylinder internal pressure PEVC at the time of exhaust air bulb clausilium (step 11), A means to compute gas constant REX corresponding to the exhaust gas presentation change according to a combustion air-fuel ratio (step 9), A means (step 10) to compute MAP PIN, and a means to compute the ratio of specific beat SHEATR corresponding to exhaust gas presentation change (step 14), A means to compute the addition effective area ASUMOL under overlap of an exhaust air bulb open period and an intake valve open period (step 14), It is constituted including a means (step 15) to compute the engine engine speed NRPM, and a means (steps 27 and 32) to judge the existence of supercharge and a choke, and blows under overlap based on these calculation values, and capacity MRESOL is computed. For this reason, based on the quantity of state under overlap (temperature TEVC, a pressure PEVC, gas constant REX, area ASUMOL), it blows by the physical formula (seven formulas), and capacity MRESOL can be computed with a sufficient precision. And it can respond to the consistency change and orifice passage volumetric flow rate change by change of a quantity of state, and blows with a sufficient precision during overlap in all operational status, and capacity MRESOL can be computed. Furthermore, also in the control construction containing a multi-dimension parameter, in order to compute the amount MRES of internals EGR based on a physical type (three formulas) according to each parameter, it can build easily and adaptation becomes easy.

[0065]

Moreover, according to this operation gestalt, based on the cylinder internal pressure PEVC, supercharge and the judgment means (steps 27 and 32) of a choke are equipped with a means (step 26) to compute the inhalation-of-air exhaust-gas-pressure ratio PINBYEX, and at the time of MAP PIN and exhaust air bulb clausilium, when a supercharge judging means (step 27) makes the ratio of specific beat SHEATR corresponding to exhaust gas presentation change those with supercharge, they set it up. For this reason, also in the time of inertia supercharging in full admission operation, and the supercharge by the supercharger, it blows under overlap with a sufficient precision, and capacity MRESOL can be computed. And even when a choke is generated in the time of idle operation etc., it blows with a sufficient precision and capacity MRESOL can be computed.

[0066]

moreover, a means (drawing 20) to compute a means (drawing 20) by which an addition effective-area calculation means (step 14) computes intake valve closing motion timing during overlap, and exhaust air bulb closing motion timing according to this operation gestalt -- since -- the amount of overlap is computed and it asks for the addition effective area ASUMOL according to this amount of overlap. For this reason, the addition effective area ASUMOL can be computed based on the amount of overlap, and count by the physical type (six formulas) can be simplified.

[0067]

Moreover, according to this operation gestalt, during overlap, an addition effective-area calculation means (step 14) integrates with either minimum value of the opening area in an inhalation-of-air valve lift, and the opening area in an exhaust air valve lift, and computes the addition effective area ASUMOL. For this reason, false [of the addition effective area ASUMOL of an overlap period] can be carried out as one orifice, and the flow rate which passes this orifice from the condition of an exhaust air system and the condition of an inhalation-of-air system can be computed in simple.

[Brief Description of the Drawings]

[Drawing 1] System configuration drawing of the amount presumption equipment of internals EGR

[Drawing 2] The control block diagram of the rate calculation means of internal EGR

[Drawing 3] The control block diagram of the amount calculation means of internals EGR

[Drawing 4] It is the control block diagram of the quantity-of-gas-flow calculation means in a cylinder at the time of exhaust air bulb clausilium.

[Drawing 5] It blows during overlap and is the control block diagram of a capacity calculation means.

[Drawing 6] The control block diagram of an exhaust gas ratio-of-specific-beat calculation means

[Drawing 7] The control block diagram of supercharge and a choke judging means

[Drawing 8] Rate calculation flow chart of internal EGR
[Drawing 9] The amount calculation flow chart of internals EGR
[Drawing 10] It is a capacity calculation flow chart in a cylinder at the time of exhaust air bulb clausilium.
[Drawing 11] It blows during overlap and is a capacity calculation flow chart.
[Drawing 12] A supercharge judging and a choke judging flow chart
[Drawing 13] It blows during overlap at the time of supercharge-less - choke nothing, and is a quantity-of-gas-flow calculation flow chart.
[Drawing 14] It blows during overlap at the time of those with supercharge-less - choke, and is a quantity-of-gas-flow calculation flow chart.
[Drawing 15] It blows during overlap at the time of those with supercharge, and choke nothing, and is a quantity-of-gas-flow calculation flow chart.
[Drawing 16] It blows during overlap at the time of those with supercharge, and those with a choke, and is a quantity-of-gas-flow calculation flow chart.
[Drawing 17] It is a cylinder content volume calculation table at the time of exhaust air bulb clausilium.
[Drawing 18] Exhaust gas gas constant calculation table
[Drawing 19] It is an addition effective-area calculation table during overlap.
[Drawing 20] It is the explanatory view of addition effective area during overlap.
[Drawing 21] Exhaust gas ratio-of-specific-beat calculation table
[Drawing 22] gaseous mixture -- a ratio-of-specific-beat calculation table
[Description of Notations]
1 Engine
5 Intake Valve
6 Exhaust Air Bulb
10 MAP Sensor
11 Exhaust-Gas-Pressure Sensor
12 Exhaust-gas-Temperature Sensor
13 O2 Sensor
14 Crank Angle Sensor
15 Coolant Temperature Sensor
16 Inspired Air Flow Path Cam Angle Sensor
17 Exhaust Side Cam Angle Sensor
18 Accelerator Opening Sensor
30 ECU

[Translation done.]

* NOTICES *

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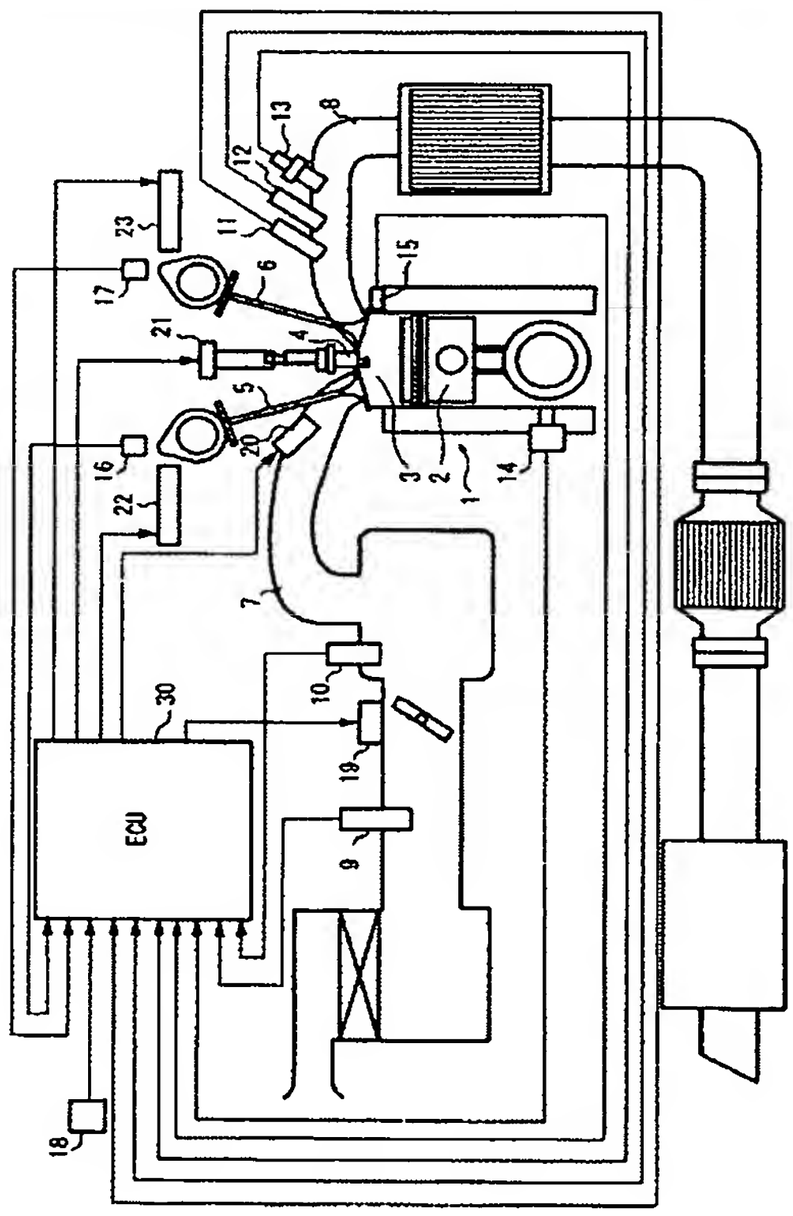
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]



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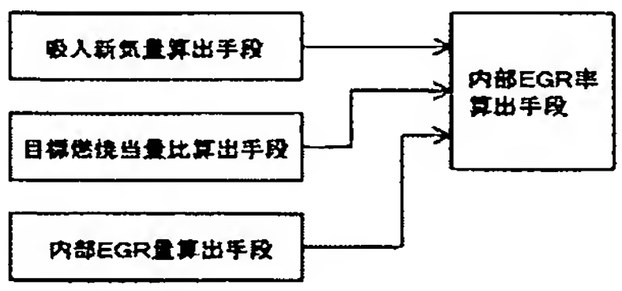

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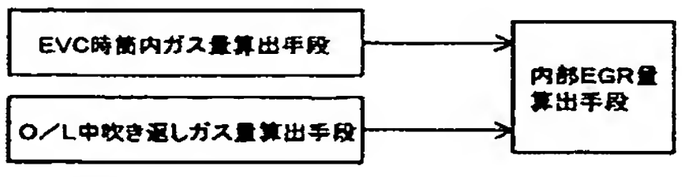

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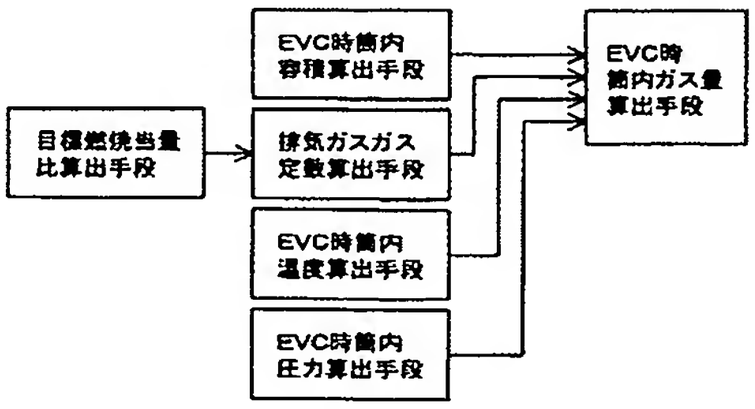

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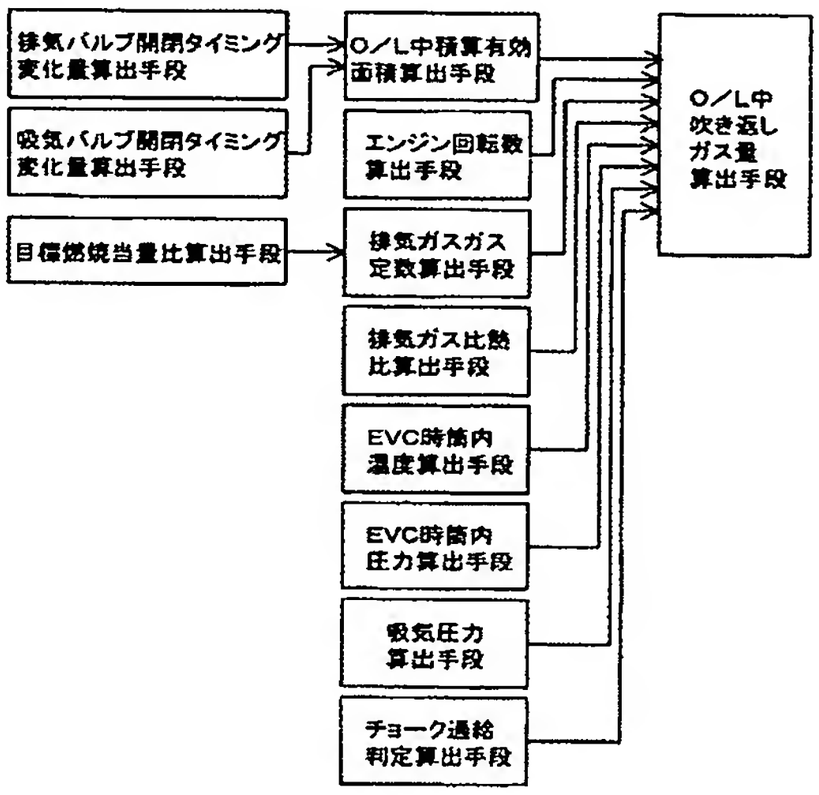

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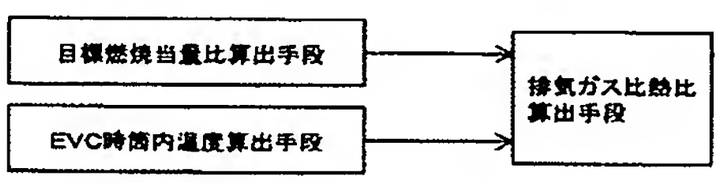

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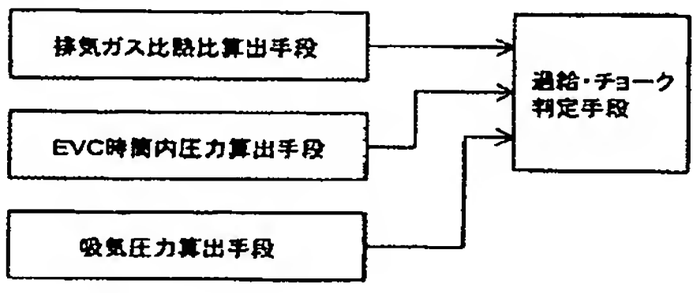

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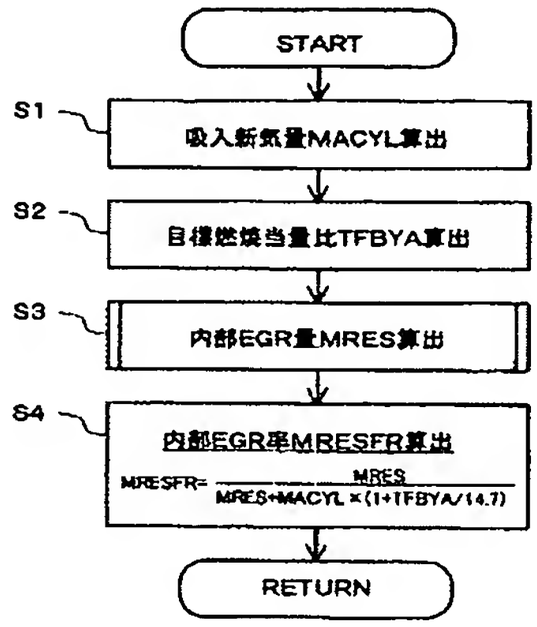

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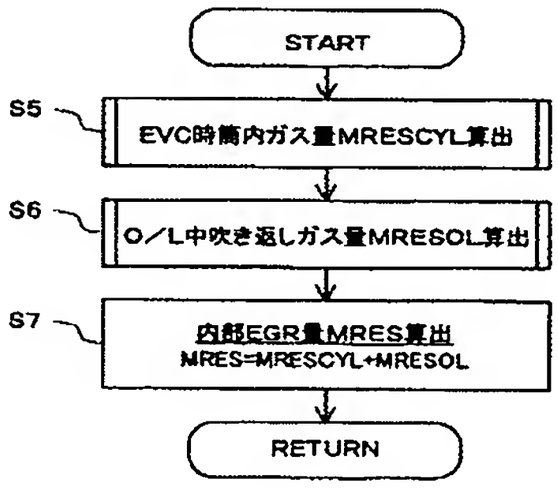

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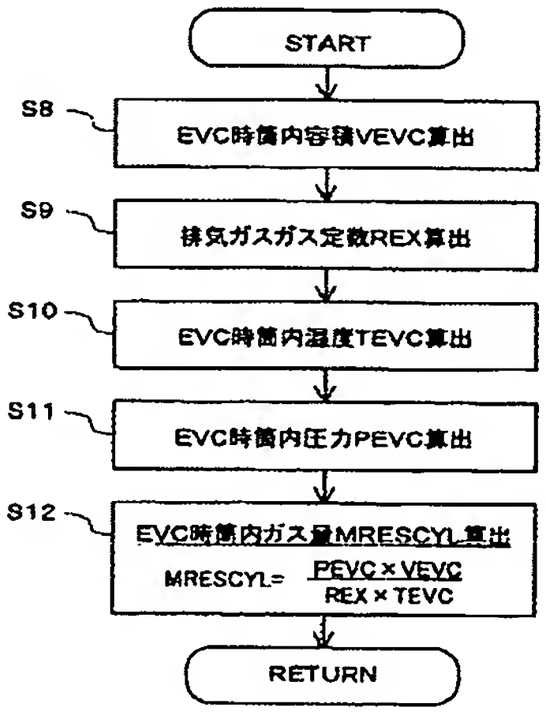

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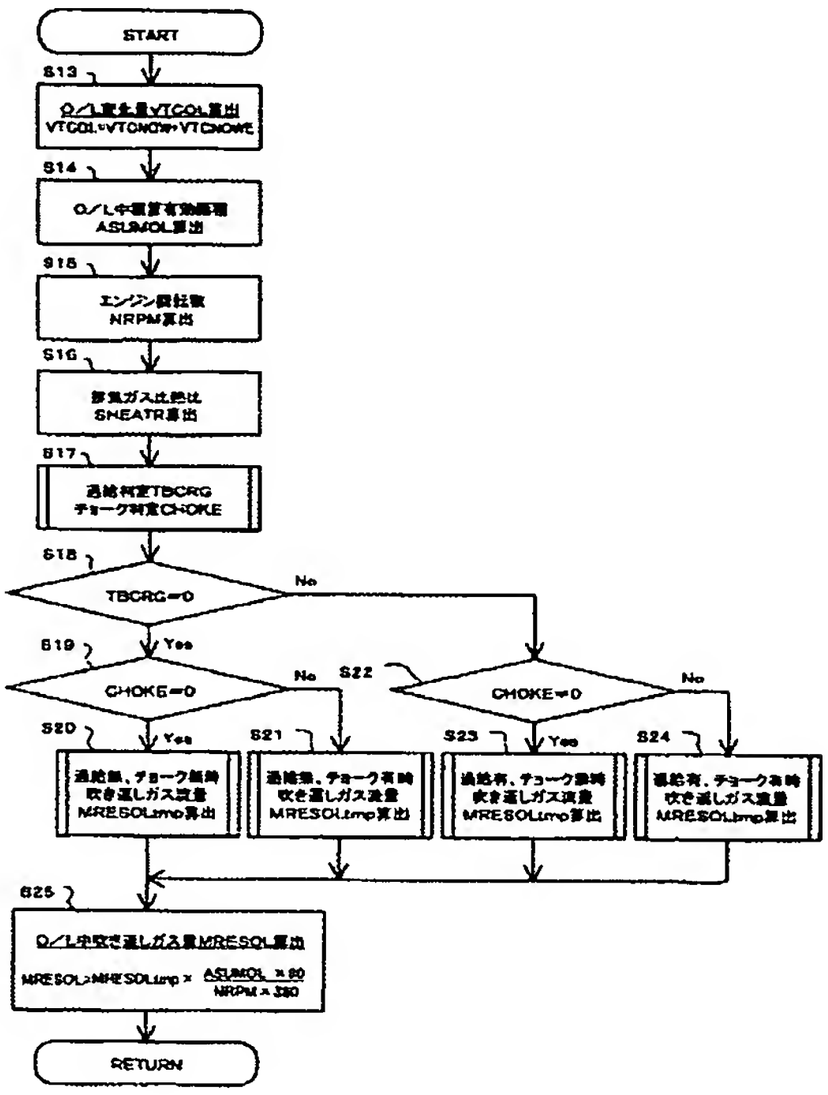

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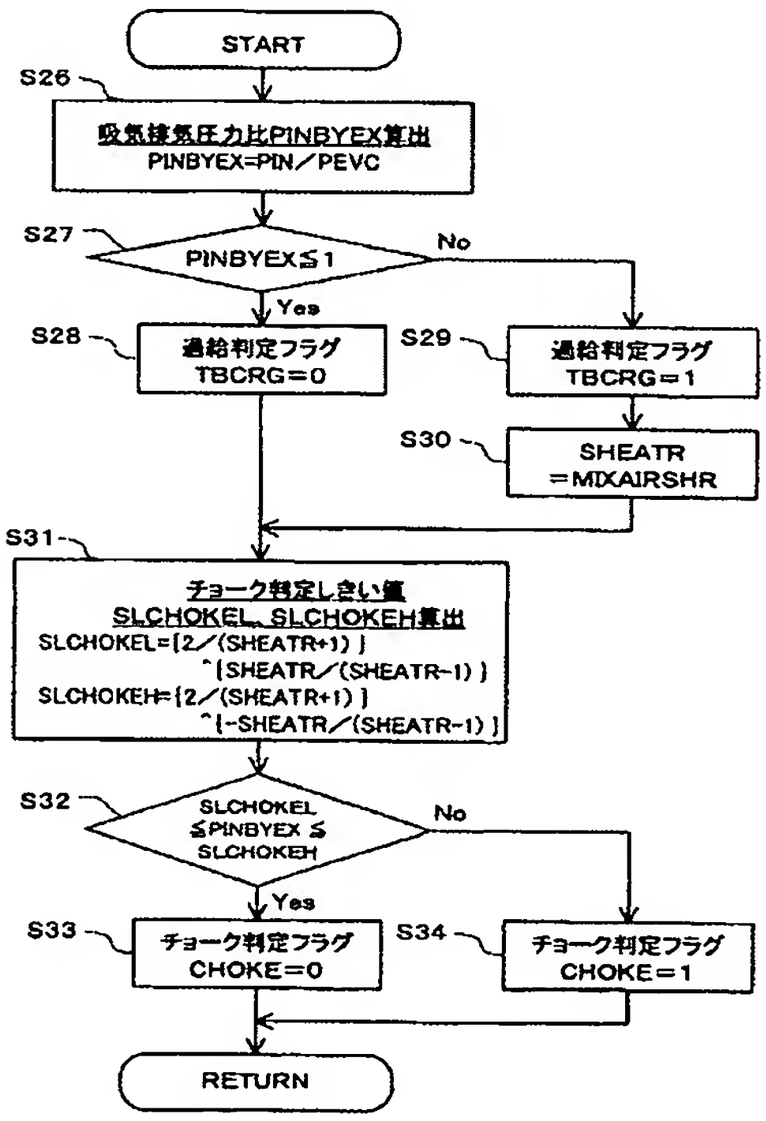

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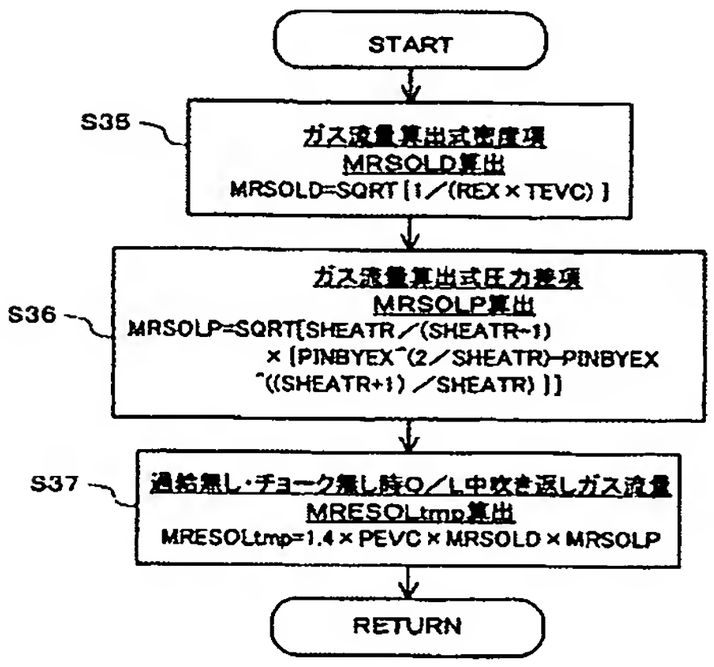

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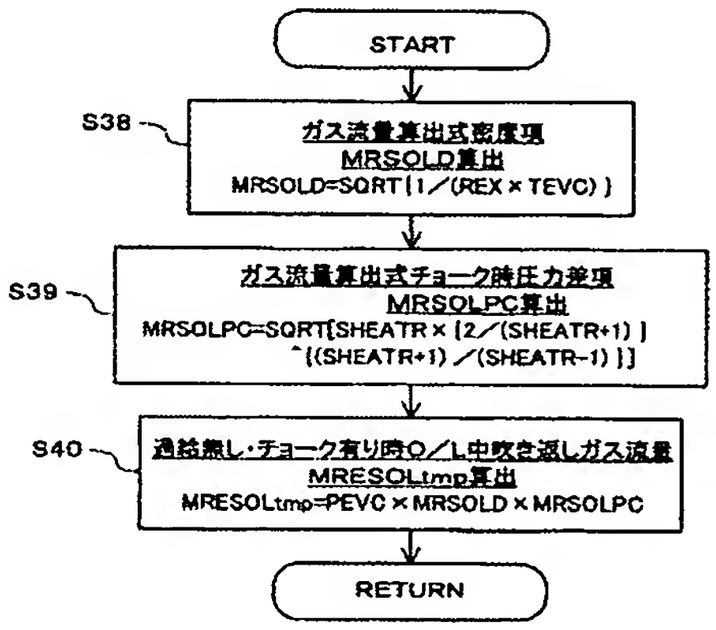

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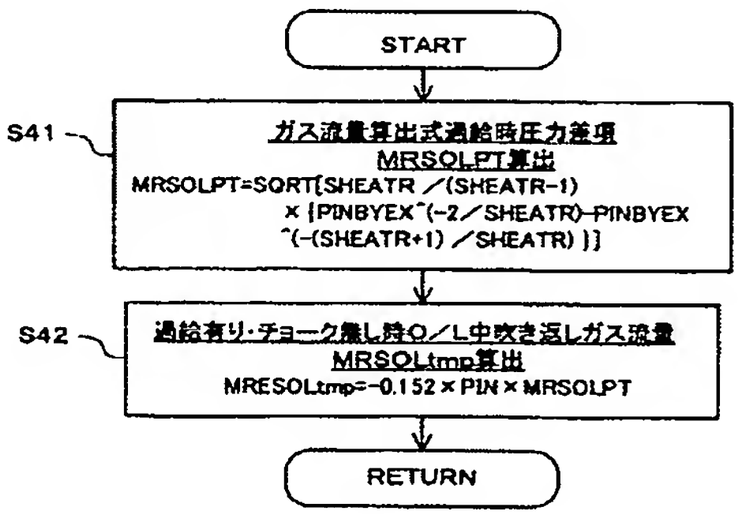

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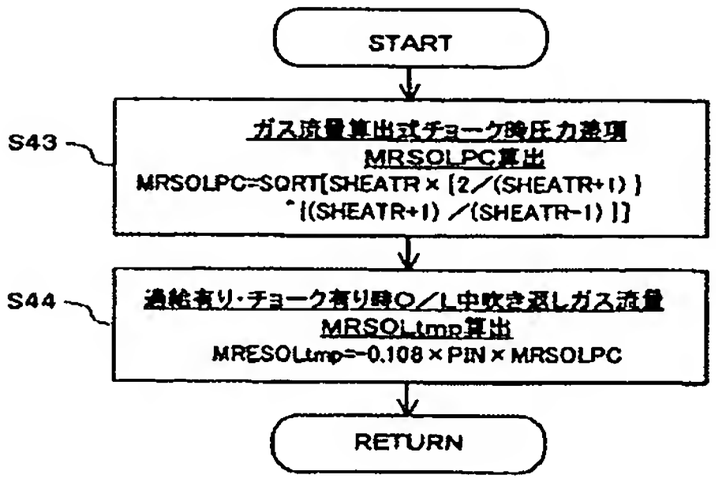

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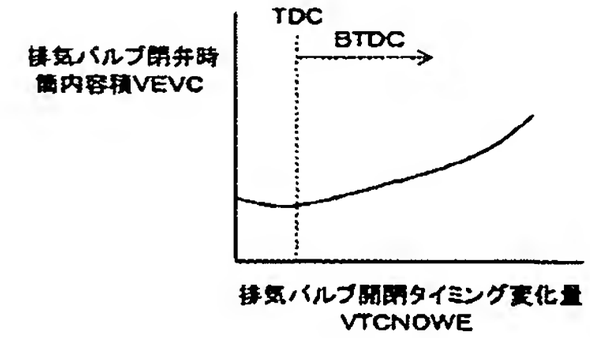

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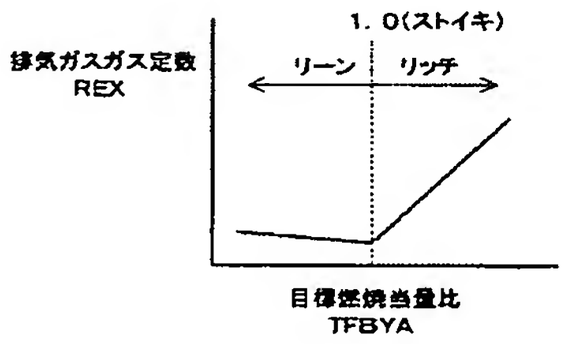

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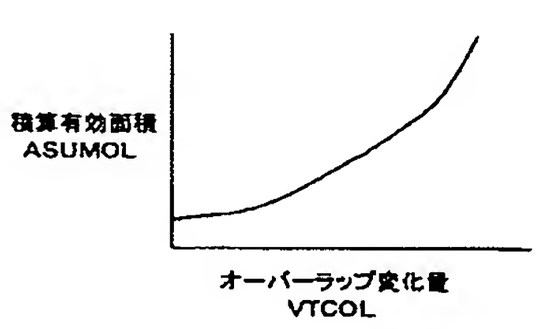

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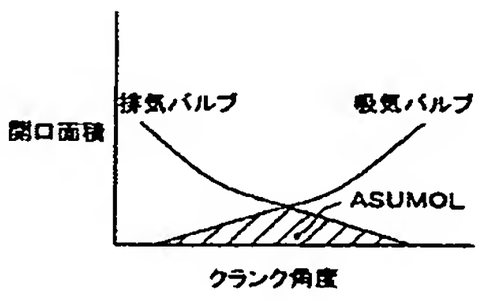

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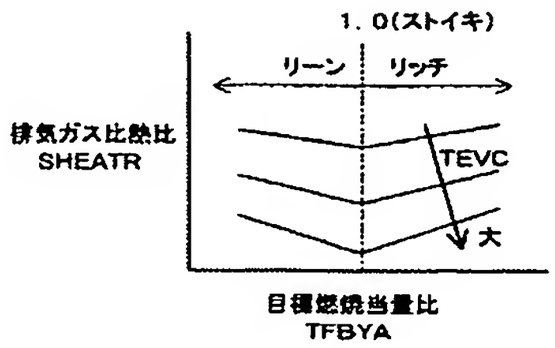

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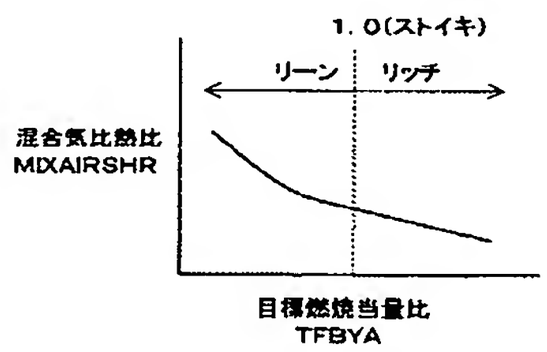

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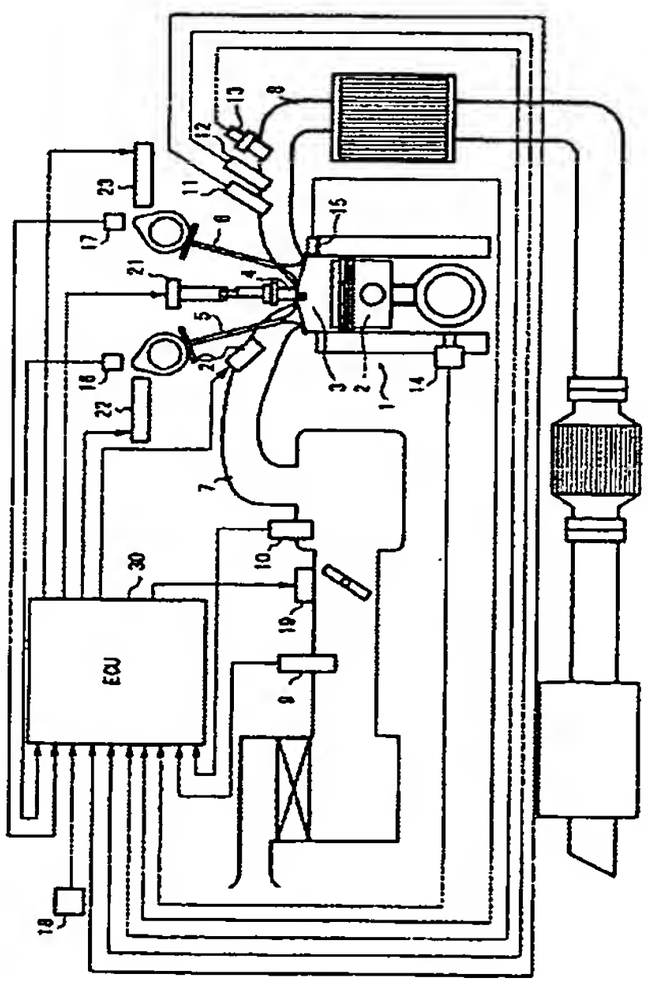
(54)【発明の名称】内燃機関の内部ＥＧＲ量推定装置

(57)【要約】
【課題】機関のシリンダ内部の状態量から物理式に基づいて内部ＥＧＲ量を精度良く推定する。
【解決手段】排気バルブ閉弁時において、排気温度センサ１２、吸気圧力センサ１０、排気圧力センサ１１の信号に基づいて、筒内温度、筒内圧力を算出し、燃焼空燃比に応じた排気ガスのガス定数を算出し、筒内ガス量を算出する。そして、クランク角センサ１４、水温センサ１５、カム角センサ１６，１７、アクセル開度センサ１８の信号に基づいて、吸気バルブ開期間及び排気バルブ開期間のオーバーラップ中の吹き返しガス量を算出する。そして、筒内ガス量と吹き返しガス量との算出値に基づいて、内部ＥＧＲ量を算出する。
【選択図】 図１



【特許請求の範囲】
【請求項１】
排気バルブ閉弁時の筒内温度を算出する手段と、
排気バルブ閉弁時の筒内圧力を算出する手段と、
燃焼空燃比に応じた排気ガス組成のガス定数を算出する手段と、
少なくとも前記筒内温度、前記筒内圧力、前記ガス定数に基づいて、排気バルブ閉弁時の筒内ガス量を算出する手段と、
排気バルブ開期間と吸気バルブ開期間とのオーバーラップ中の吹き返しガス量を算出する手段と、を備え、
前記筒内ガス量と前記吹き返しガス量とに基づいて、内部ＥＧＲ量を算出することを特徴とする内燃機関の内部ＥＧＲ量推定装置。
【請求項２】
前記排気バルブ閉弁時筒内ガス量算出手段は、
排気バルブ閉弁時の筒内容積を算出する手段と、
前記排気バルブ閉弁時の筒内温度を算出する手段と、
前記排気バルブ閉弁時の筒内圧力を算出する手段と、
前記燃焼空燃比に応じた排気ガス組成のガス定数を算出する手段と、
を含んで構成され、これらの算出値に基づいて、物理式により排気バルブ閉弁時の筒内ガス量を算出することを特徴とする請求項１記載の内燃機関の内部ＥＧＲ量推定装置。
【請求項３】
前記排気バルブ閉弁時筒内容積算出手段は、排気バルブ閉弁時のピストン位置から幾何学的に決まる筒内容積値を求めることを特徴とする請求項２記載の内燃機関の内部ＥＧＲ量推定装置。
【請求項４】
前記排気バルブ閉弁時筒内容積算出手段は、排気バルブ閉弁時期と該時期の筒内容積とを相対的に変化させる機構を有する機関においては、それらの変化量に応じて、排気バルブ閉弁時の筒内容積値を求めることを特徴とする請求項２記載の内燃機関の内部ＥＧＲ量推定装置。
【請求項５】
前記ガス定数算出手段は、目標燃焼当量比に応じ、排気ガス組成の変化に対応するガス定数を求めることを特徴とする請求項１～請求項４のいずれか１つに記載の内燃機関の内部ＥＧＲ量推定装置。
【請求項６】
前記オーバーラップ中吹き返しガス量算出手段は、
前記排気バルブ閉弁時の筒内温度を算出する手段と、
前記排気バルブ閉弁時の筒内圧力を算出する手段と、
前記燃焼空燃比に応じた排気ガス組成変化に対応したガス定数を算出する手段と、
吸気圧力を算出する手段と、
排気ガス組成変化に対応した比熱比を算出する手段と、
排気バルブ開期間と吸気バルブ開期間とのオーバーラップ中の積算有効面積を算出する手段と、
機関回転数を算出する手段と、
過給及びチョークの有無を判定する手段と、
を含んで構成され、これらの算出値に基づいて、オーバーラップ中の吹き返しガス量を算出することを特徴とする請求項１～請求項５のいずれか１つに記載の内燃機関の内部ＥＧＲ量推定装置。
【請求項７】
前記過給及びチョークの判定手段は、
前記吸気圧力と前記排気バルブ閉弁時筒内圧力とに基づいて、吸気排気圧力比を算出する手段を備え、

前記排気ガス組成変化に対応した比熱比を、前記過給判定手段が過給有りとした場合に設定することを特徴とする請求項６記載の内燃機関の内部ＥＧＲ量推定装置。
【請求項８】
前記オーバーラップ中積算有効面積算出手段は、
吸気バルブ開閉タイミングを算出する手段と、
排気バルブ開閉タイミングを算出する手段と、
からオーバーラップ量を算出し、
このオーバーラップ量に応じて有効面積の積算値を求めることを特徴とする請求項６または請求項７記載の内燃機関の内部ＥＧＲ量推定装置。
【請求項９】
前記オーバーラップ中積算有効面積算出手段は、
吸気バルブリフト中の開口面積と排気バルブリフト中の開口面積とのいずれか一方の最小値を積分して、積算有効面積を算出することを特徴とする請求項６または請求項７記載の内燃機関の内部ＥＧＲ量推定装置。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】
本発明は、内燃機関の内部ＥＧＲ量（排出ガスの還流量）推定装置に関する。
【０００２】
【従来の技術】
従来から火花点火式内燃機関では、不活性成分増大化による燃焼温度抑制によるＮＯｘ（窒素酸化物）の低減と、ポンプロスの低減による燃費低減とを図るために、可変動弁機構を利用して、排気バルブ開期間と吸気バルブ開期間とのオーバーラップ量を拡大し、内部ＥＧＲ量を増加させるものがある。この場合、内部ＥＧＲ量に応じて、点火時期、燃料噴射量、バルブ開閉タイミングなどを補正する制御を行うことが望ましい。
【０００３】
また、特許文献１には、オーバーラップ無し時の機関の運転条件（負荷・回転数・空燃比・ＥＧＲ率・吸気負圧など）から内部ＥＧＲ量の基本値を算出し、オーバーラップ時の運転条件の変化量に応じて内部ＥＧＲ量を補正することが開示されている。
【０００４】
【特許文献１】
特開２００１－２２１１０５号公報
【０００５】
【発明が解決しようとする課題】
しかしながら、運転状態が変化し、負荷・回転数・燃焼空燃比・吸気負圧などの組み合わせが変化することで、オーバーラップ量により内部ＥＧＲ量を一義的に推定することは困難であった。
また、特許文献１では、運転条件の変化量から内部ＥＧＲ量を補正する場合には、各パラメータの変化により算出された内部ＥＧＲ量の精度は十分なものではなかった。
【０００６】
本発明は上記問題を解決するためになされたものであり、機関の運転条件に応じて内部ＥＧＲ量を精度良く推定することを目的とする。
【０００７】
【課題を解決するための手段】
そのため本発明では、排気バルブ閉弁時の筒内温度、排気バルブ閉弁時の筒内圧力、燃焼空燃比に応じた排気ガス組成のガス定数を各々算出して、少なくともこれらに基づいて、排気バルブ閉弁時の筒内ガス量を算出する。そして、排気バルブ開期間と吸気バルブ開期間とのオーバーラップ中の吹き返しガス量を算出する。そして、筒内ガス量と吹き返しガス量とに基づいて、内部ＥＧＲ量を算出する。
【０００８】

【発明の効果】
本発明によれば、運転条件に関わらず、燃焼終了後のシリンダ内部の状態量（温度・圧力・排気ガスのガス定数）に基づき、精度良く内部ＥＧＲ量を推定できる。
【０００９】
【発明の実施の形態】
以下、図面に基づき本発明の実施形態について説明する。
図１は、内燃機関の内部ＥＧＲ量推定装置のシステム構成図である。
エンジン１の各気筒のピストン２により画成される燃焼室３には、点火プラグ４を囲むように、吸気バルブ５と排気バルブ６とを備えている。吸気バルブ５及び排気バルブ６のリフト特性（開閉時期）は、吸気側及び排気側に設けられた可変動弁ソレノイド２２，２３により、カム軸に対するカムの位相を変化させることで、バルブタイミングの制御が可能である。
【００１０】
吸気通路７には、電子制御スロットル弁１９が設けられており、これにより吸入新気量が制御される。燃料の供給は、吸気通路７に気筒毎に（または各燃焼室３に直接臨ませて）設けたインジェクタ２０によりなされる。燃焼室３内で混合気は点火プラグ４により点火されて燃焼し、排気通路８へ排出される。
ここで、電子制御スロットル弁１９、インジェクタ２０、点火プラグ４（パワトラ内蔵点火コイル２１）、可変動弁ソレノイド２２，２３の作動は、エンジンコントロールユニット（ＥＣＵ）３０により制御される。
【００１１】
これらの制御のため、ＥＣＵ３０には、各種センサからの信号が入力されている。
クランク角センサ１４は、エンジン回転に同期してクランク角信号を出力し、これによりクランク角位置と共にエンジン回転数を検出可能である。そして、カム角センサ１６，１７は、吸気バルブ５及び排気バルブ６のカム角を検出可能であり、これにより可変動弁ソレノイド２２，２３の作動状態を検出可能である。
【００１２】
そして、吸気通路７にて吸入新気量を検出するエアフロメータ９、電子制御スロットル弁１９下流にて吸気圧力を検出する吸気圧力センサ１０、排気通路７にて排気圧力を検出する排気圧力センサ１１、排気通路８にて排気温度を検出する排気温度センサ１２、排気通路８にて排気中に含まれる酸素量を検出するＯ２センサ（酸素センサ）１３、エンジン１の冷却水温度を検出する水温センサ１５、アクセル開度を検出するアクセル開度センサ１８の出力信号もＥＣＵ３０に入力され、これらの状態を検出可能である。
【００１３】
次に、ＥＣＵ３０が行う内部ＥＧＲ量及び内部ＥＧＲ率の推定について以下に説明する。
図２～図７は制御構成図であり、図８～図１６は制御フローチャートであり、図１７～図２２は各値を求めるテーブルである。
内部ＥＧＲ率ＭＲＥＳＦＲの算出について、図２の内部ＥＧＲ率算出手段の制御構成図と、図８の内部ＥＧＲ率ＭＲＥＳＦＲ算出フローとを用いて説明する。
【００１４】
図２に示す吸入新気量算出手段は吸入新気量（新気質量）ＭＡＣＹＬ、目標燃焼当量比算出手段は目標燃焼当量比ＴＦＢＹＡ、内部ＥＧＲ量算出手段は内部ＥＧＲ量ＭＲＥＳをそれぞれ算出し、これらの算出値に基づいて、内部ＥＧＲ率算出手段は内部ＥＧＲ率ＭＲＥＳＦＲを算出する。
図８のステップ１では、エアフロメータ９により計測された吸入新気量に基づいて１シリンダ当たりの吸入新気量ＭＡＣＹＬを算出する。
【００１５】
ステップ２では、クランク角センサ１４の信号に基づいて検出されるエンジン回転数と、アクセル開度センサ１８の信号に基づいて検出されるアクセル開度と、水温センサ１５の信号に基づいて検出される冷却水温度とに応じて決まる目標燃焼当量比ＴＦＢＹＡを算出

する。
なお、目標燃焼当量比ＴＦＢＹＡは、理論空燃比を１４．７とすると、目標燃焼空燃比より次式により表され、目標燃焼空燃比がストイキのときに１となる。
【００１６】
ＴＦＢＹＡ＝１４．７／目標燃焼空燃比・・・（１）
ステップ３では、後述する図９のフローチャートに従って、１シリンダ当たりの内部ＥＧＲ量ＭＲＥＳを算出する。
ステップ４では、内部ＥＧＲ率ＭＲＥＳＦＲ（１シリンダ当たりの総ガス量に対する内部ＥＧＲ量の割合）を次式により算出し、処理を終了する。
【００１７】
ＭＲＥＳＦＲ＝ＭＲＥＳ／｛ＭＲＥＳ＋ＭＡＣＹＬ×（１＋ＴＦＢＹＡ／１４．７）｝・・・（２）
ここで、ステップ３の内部ＥＧＲ量ＭＲＥＳの算出について、図３の内部ＥＧＲ量算出手段の制御構成図と、図９の内部ＥＧＲ量算出フローとを用いて説明する。
【００１８】
図３に示す排気バルブ閉弁時（図には「ＥＶＣ時」と示す）筒内ガス量算出手段は筒内ガス量ＭＲＥＳＣＹＬ、吸気バルブ５及び排気バルブ６のオーバーラップ（図には「Ｏ／Ｌ」と示す）中吹き返しガス量算出手段は吹き返しガス量ＭＲＥＳＯＬをそれぞれ算出し、これらの算出値に基づいて、内部ＥＧＲ量算出手段は内部ＥＧＲ量ＭＲＥＳを算出する。
【００１９】
図９のステップ５では、後述する図１０のフローチャートに従って、排気バルブ閉弁時においてシリンダ内部に残留しているガス量である排気バルブ閉弁時筒内ガス量ＭＲＥＳＣＹＬを算出する。
ステップ６では、後述する図１１のフローチャートに従って、オーバーラップ中に排気側から吸気側へ吹き返すガス量であるオーバーラップ中吹き返しガス量ＭＲＥＳＯＬを算出する。
【００２０】
ステップ７では、排気バルブ閉弁時筒内ガス量ＭＲＥＳＣＹＬとオーバーラップ中吹き返しガス量ＭＲＥＳＯＬとを加算して、内部ＥＧＲ量ＭＲＥＳを次式により算出する。
ＭＲＥＳ＝ＭＲＥＳＣＹＬ＋ＭＲＥＳＯＬ・・・（３）
ここで、ステップ５の排気バルブ閉弁時筒内ガス量ＭＲＥＳＣＹＬの算出について、図４の排気バルブ閉弁時筒内ガス量算出手段の制御構成図と、図１０の排気バルブ閉弁時筒内ガス量ＭＲＥＳＣＹＬ算出フローとを用いて説明する。
【００２１】
図４に示す目標燃焼当量比算出手段は排気ガスの目標燃焼当量比ＴＦＢＹＡを算出し、この値に基づき、排気ガスガス定数算出手段はガス定数ＲＥＸを算出する。排気バルブ閉弁時筒内容積算出手段は筒内容積ＶＥＶＣ、排気バルブ閉弁時筒内温度算出手段は筒内温度ＴＥＶＣ、排気バルブ閉弁時圧力算出手段は筒内圧力ＰＥＶＣをそれぞれ算出する。そして、これらの算出値に基づき、排気バルブ閉弁時筒内ガス量算出手段は筒内ガス量ＭＲＥＳＣＹＬを算出する。
【００２２】
図１０のステップ８では、図１７に示すテーブルから排気バルブ閉弁時筒内容積ＶＥＶＣを求める。図１７は、排気バルブ閉弁時筒内容積ＶＥＶＣ算出テーブルであり、横軸は排気バルブ開閉タイミング変化量ＶＴＣＮＯＷＥ、縦軸は排気バルブ閉弁時筒内容積ＶＥＶＣを示している。
ここで、排気バルブ閉弁時期を変化させる機構を有するエンジンにおいては、排気側のカム角センサ１７の信号に基づいて検出される排気バルブ開閉タイミング変化量ＶＴＣＮＯＷＥに応じて、図１７に示す排気バルブ閉弁時筒内容積ＶＥＶＣをテーブルから求める。
【００２３】
なお、圧縮比を変化させる機構を有するエンジンにおいては、圧縮比の変化量に応じた排

気バルブ閉弁時筒内容積ＶＥＶＣをテーブルから求める。
また、排気バルブ閉弁時期と圧縮比とを同時に可変とする機構を有するエンジンにおいては、排気バルブ閉弁時期と圧縮比変化量とに応じた排気バルブ閉弁時筒内容積ＶＥＶＣをテーブルから求める。
【００２４】
図１０のステップ９では、図１８に示すテーブルから目標燃焼当量比ＴＦＢＹＡに応じた排気ガスのガス定数ＲＥＸを求める。図１８は、排気ガスガス定数ＲＥＸ算出テーブルであり、横軸は目標燃焼当量比ＴＦＢＹＡ、縦軸は排気ガスのガス定数ＲＥＸを示している。なお、図１８中の点線はストイキを示している。
ステップ１０では、排気温度センサ１２の信号に基づいて検出した排気温度に基づいて、排気バルブ閉弁時筒内温度ＴＥＶＣを推定する。なお、排気バルブ閉弁時筒内温度ＴＥＶＣは、インジェクタ２０の燃料噴射量に応じた熱量により変化するため、このような特性を利用したテーブルから求めてもよい。
【００２５】
ステップ１１では、排気圧力センサ１１の信号に基づいて検出された排気圧力に基づいて、排気バルブ閉弁時筒内圧力ＰＥＶＣを推定する。なお、排気バルブ閉弁時筒内圧力ＰＥＶＣは、混合気体積と排気系の管内抵抗とで決まるため、混合気体積流量に応じたテーブルから求めてもよい。
ステップ１２では、ステップ８～ステップ１１において算出された排気バルブ閉弁時筒内容積ＶＥＶＣ、排気ガスガス定数ＲＥＸ、排気バルブ閉弁時筒内温度ＴＥＶＣ、排気バルブ閉弁時筒内圧力ＰＥＶＣの算出値から、排気バルブ閉弁時においてシリンダ内部に残留している排気バルブ閉弁時筒内ガス量ＭＲＥＳＣＹＬを次式により算出する。
【００２６】
ＭＲＥＳＣＹＬ＝（ＰＥＶＣ×ＶＥＶＣ）／（ＲＥＸ×ＴＥＶＣ）・・・（４）
ここで、図９のステップ６のオーバーラップ中に排気側から吸気側へ吹き返すガス量ＭＲＥＳＯＬの算出について、図５のオーバーラップ中吹き返しガス量算出の制御構成図と、図１１のオーバーラップ中吹き返しガス量ＭＲＥＳＯＬ算出フローとを用いて説明する。
【００２７】
図５に示す排気バルブと吸気バルブとの開閉タイミング変化量算出手段は吸気バルブと排気バルブとの開閉タイミング変化量ＶＴＣＮＯＷ，ＶＴＣＮＯＷＥからオーバーラップ変化量ＶＴＣＯＬを算出し、この算出値に基づいて、オーバーラップ中積算有効面積算出手段は積算有効面積ＡＳＵＭＯＬを算出する。目標燃焼当量比算出手段は当量比ＴＦＢＹＡを算出し、この算出値に基づいて、排気ガスガス定数算出手段はガス定数ＲＥＸを算出する。そして、これらの算出値と、エンジン回転数算出手段、排気ガス比熱比算出手段、排気バルブ閉弁時筒内温度算出手段、排気バルブ閉弁時筒内圧力算出手段、吸気圧力算出手段、チョーク過給判定算出手段による各算出値とに基づいて、オーバーラップ中吹き返しガス量算出手段は吹き返しガス量ＭＲＥＳＯＬを算出する。
【００２８】
図１１のステップ１３では、吸気側カムの位相を検出するカム角センサ１６の信号に基づいて検出される吸気バルブ開閉タイミング変化量ＶＴＣＮＯＷと、排気側カムの位相を検出するカム角センサ１７の信号に基づいて検出される排気バルブ開閉タイミング変化量ＶＴＣＮＯＷＥとから、オーバーラップ変化量ＶＴＣＯＬを次式により算出する。
【００２９】
ＶＴＣＯＬ＝ＶＴＣＮＯＷ＋ＶＴＣＮＯＷＥ・・・（５）
ステップ１４では、（５）式で算出したオーバーラップ変化量ＶＴＣＯＬに応じて、図１９に示すテーブルからオーバーラップ中の積算有効面積ＡＳＵＭＯＬを求める。図１９は、オーバーラップ中の積算有効面積を算出するテーブルであり、横軸はオーバーラップ変化量ＶＴＣＯＬ、縦軸はオーバーラップ中の積算有効面積ＡＳＵＭＯＬを示している。オーバーラップ変化量ＶＴＣＯＬが大きくなると、積算有効面積ＡＳＵＭＯＬが大きくなる。

【００３０】
ここで、図２０は、オーバーラップ中の積算有効面積ＡＳＵＭＯＬの説明図であり、横軸はクランク角度、縦軸は吸気バルブ５と排気バルブ６とのそれぞれの開口面積を示している。そして、オーバーラップ中の或る時点における有効な開口面積は、排気バルブ開口面積と吸気バルブ開口面積とのうち小さい方とする。すなわち、オーバーラップ中の全期間における積算有効面積ＡＳＵＭＯＬは、吸気バルブ５及び排気バルブ６が開いている期間の積分値（図中の斜線部）として示される。
【００３１】
このようにしてオーバーラップ中積算有効面積ＡＳＵＭＯＬを算出することで、吸気バルブ５と排気バルブ６とのオーバーラップ量を１つのオリフィス（流出孔）と疑似でき、排気系の状態と吸気系の状態とからこのオリフィスを通過する流量を簡略的に算出する。
図１１のステップ１５では、クランク角センサ１４の信号に基づいてエンジン回転数ＮＲＰＭを算出する。
【００３２】
ステップ１６では、図２１に示すマップから排気ガス比熱比ＳＨＥＡＴＲを算出する。この制御構成は図６に示す。
図６に示す目標燃焼当量比算出手段は目標燃焼当量比ＴＦＢＹＡ、排気バルブ閉弁時筒内温度算出手段は筒内温度ＴＥＶＣをそれぞれ算出し、これらの算出値に基づき、排気ガス比熱比算出手段は排気ガス比熱比ＳＨＥＡＴＲを算出する。
【００３３】
図２１は、排気ガス比熱比算出マップであり、横軸は目標燃焼当量比ＴＦＢＹＡ、縦軸は排気ガス比熱比ＳＨＥＡＴＲを示している。なお、図中の点線はストイキの位置を示しており、目標燃焼当量比ＴＦＢＹＡがストイキ近傍にあるときは排気ガス比熱比ＳＨＥＡＴＲが小さくなり、リッチ側またはリーン側になると比熱比ＳＨＥＡＴＲが大きくなる。そして、排気バルブ閉弁時の筒内温度ＴＥＶＣが変化した場合を太線矢印で示す。ここで、図８のステップ２で算出した目標燃焼当量比ＴＦＢＹＡと、図１０のステップ１０で算出した排気バルブ閉弁時筒内温度ＴＥＶＣとに応じて、排気ガス比熱比ＳＨＥＡＴＲを求める。
【００３４】
ステップ１７では、後述する図７の過給・チョーク判定手段の制御構成図と、図１２の過給判定ＴＢＣＲＧ・チョーク判定ＣＨＯＫＥフローとにより、過給判定ＴＢＣＲＧ及びチョーク判定ＣＨＯＫＥを行う。
ステップ１８では、ステップ１７での過給判定フラグＴＢＣＲＧが０であるか否か、すなわち過給状態を判断する。過給判定フラグＴＢＣＲＧが０の場合は、ステップ１９へ進み、過給判定フラグＴＢＣＲＧが０でない場合は、ステップ２２へ進む。
【００３５】
ステップ１９では、ステップ１７でのチョーク判定フラグＣＨＯＫＥが０であるか否か、すなわちチョーク状態を判断する。
チョーク判定フラグＣＨＯＫＥが０の場合は、ステップ２０へ進み、後述する図１３のフローから、過給無し且つチョーク無し時のオーバーラップ中の平均吹き返しガス流量ＭＲＥＳＯＬｔｍｐを算出する。
【００３６】
一方、ステップ１９で、ステップ１７でのチョーク判定フラグＣＨＯＫＥが０でない場合には、ステップ２１へ進み、後述する図１４のフローから、過給無し且つチョーク有り時のオーバーラップ中の吹き返しガス流量ＭＲＥＳＯＬｔｍｐを算出する。
また、ステップ１８で、ステップ１７での過給判定フラグＴＢＣＲＧが１、すなわち過給状態であり、且つステップ２２でチョーク判定フラグＣＨＯＫＥが０の場合は、ステップ２３へ進み、後述する図１５のフローから、過給有り且つチョーク無し時のオーバーラップ中の平均吹き返しガス流量ＭＲＥＳＯＬｔｍｐを算出する。
【００３７】

一方、ステップ２２で、ステップ１７でのチョーク判定フラグＣＨＯＫＥが１の場合は、ステップ２４へ進み、後述する図１６のフローから、過給有り且つチョーク有り時の吹き返しガス流量ＭＲＥＳＯＬｔｍｐを算出する。
ステップ２０，２１，２３，２４で吹き返しガス流量ＭＲＥＳＯＬｔｍｐを算出した後は、ステップ２５へ進む。

【００３８】

ステップ２５では、過給の有無とチョークの有無との状態に応じて、吹き返しガス流量ＭＲＥＳＯＬｔｍｐとオーバーラップ期間中の積算有効面積ＡＳＵＭＯＬとを積算することで、オーバーラップ中の吹き返しガス量ＭＲＥＳＯＬを次式により算出する。

ＭＲＥＳＯＬ＝（ＭＲＥＳＯＬｔｍｐ×ＡＳＵＭＯＬ×６０）／（ＮＲＰＭ×３６０）・・・（７）

ここで、ステップ１７における過給・チョーク判定について、図７の過給・チョーク判定手段の制御構成図と、図１２の過給判定ＴＢＣＲＧ・チョーク判定ＣＨＯＫＥフローとを用いて説明する。

【００３９】

図７に示す通り、排気ガス比熱比算出手段、排気バルブ閉弁時筒内圧力算出手段、吸気圧力算出手段の各算出値に基づき、過給・チョーク判定手段は過給判定ＴＢＣＲＧとチョーク判定ＣＨＯＫＥとを行う。
図１２のステップ２６では、吸気圧力センサ１０の信号に基づいて検出された吸気圧力ＰＩＮと、図１０のステップ１１で算出された排気バルブ閉弁時筒内圧力ＰＥＶＣとの比、すなわち吸気排気圧力比ＰＩＮＢＹＥＸを次式により算出する。

【００４０】

ＰＩＮＢＹＥＸ＝ＰＩＮ／ＰＥＶＣ・・・（８）

ステップ２７では、吸気排気圧力比ＰＩＮＢＹＥＸが１以下であるか否か、すなわち過給状態を判断する。
吸気排気圧力比ＰＩＮＢＹＥＸが１以下の場合、すなわち過給無しの場合は、ステップ２８へ進み、過給判定フラグＴＢＣＲＧ＝０を０に設定し、ステップ３１へ進む。

【００４１】

一方、吸気排気圧力比ＰＩＮＢＹＥＸが１より大きい場合、すなわち過給有りの場合は、ステップ２９へ進み、過給判定フラグＴＢＣＲＧを１に設定し、ステップ３０へ進み、図１１のステップ１６で算出した排気ガス比熱比ＳＨＥＡＴＲを、図２２に示すテーブルから求めた空気及び燃料の混合気比熱比ＭＩＸＡＩＲＳＨＲとする。

【００４２】

図２２は、混合気比熱比ＭＩＸＡＩＲＳＨＲ算出テーブルであり、横軸は目標燃焼当量比ＴＦＢＹＡ、縦軸は混合気比熱比ＭＩＸＡＩＲＳＨＲを示している。なお、図中の点線はストイキを示し、比熱比ＭＩＸＡＩＲＳＨＲは、リーン側のときは大きく、リッチ側のときは小さくなる。そして、図２のステップ２で算出した目標燃焼当量比ＴＦＢＹＡに対応する混合気比熱比ＭＩＸＡＩＲＳＨＲをテーブルから求める。

【００４３】

そして、ステップ３０において、排気ガス比熱比ＳＨＥＡＴＲを混合気比熱比ＭＩＸＡＩＲＳＨＲに置き換えることで、ターボ過給や慣性過給等の過給時におけるオーバーラップ中のガス流れが吸気系から排気系へ向かう（吹き抜ける）ときにおいても、オリフィスを通過するガスの比熱比を排気ガスの比熱比から吸気混合気の比熱比に変更することにより、吹き抜けるガス量を精度良く推定し、内部ＥＧＲ量を精度良く算出する。

【００４４】

ステップ３１では、ステップ１６またはステップ３０で算出した排気ガス比熱比ＳＨＥＡＴＲに基づき、最小と最大とのチョーク判定しきい値ＳＬＣＨＯＫＥＬ，ＳＬＣＨＯＫＥＨを次式により算出する。

ＳＬＣＨＯＫＥＬ＝｜２／（ＳＨＥＡＴＲ＋１）｜＾｜ＳＨＥＡＴＲ／（ＳＨＥＡＴＲ－１）｜・・・（９ａ）

ＳＬＣＨＯＫＥＨ＝｜２／（ＳＨＥＡＴＲ＋１）｜＾｜－ＳＨＥＡＴＲ／（ＳＨＥＡＴＲ－１）｜・・・（９ｂ）
このチョーク判定しきい値ＳＬＣＨＯＫＥＬ，ＳＬＣＨＯＫＥＨは、チョークする限界値を算出している。
【００４５】
また、ステップ３１において、制御構成上、累乗計算が困難な場合には、予め、（９ａ），（９ｂ）式の計算結果を、最小チョーク判定しきい値ＳＬＣＨＯＫＥＬテーブルと最大チョーク判定しきい値ＳＬＣＨＯＫＥＨテーブルとして記憶しておき、排気ガス比熱比ＳＨＥＡＴＲに応じて求めてもよい。
ステップ３２では、ステップ２６で算出した吸気排気圧力比ＰＩＮＢＹＥＸが、最小チョーク判定しきい値ＳＬＣＨＯＫＥＬ以上で且つ最大チョーク判定しきい値ＳＬＣＨＯＫＥＨ以下の範囲内にあるか否か、すなわちチョーク状態を判定する。
【００４６】
吸気排気圧力比ＰＩＮＢＹＥＸが範囲内にある場合、すなわちチョーク無しと判断した場合は、ステップ３３へ進み、チョーク判定フラグＣＨＯＫＥを０に設定する。
一方、吸気排気圧力比ＰＩＮＢＹＥＸが範囲内にない場合、すなわちチョーク有りと判断した場合は、ステップ３４へ進み、チョーク判定フラグＣＨＯＫＥを１に設定する。
【００４７】
また、図１１のステップ２０の吹き返しガス流量ＭＲＥＳＯＬｔｍｐの算出について、図１３の過給無し且つチョーク無し時オーバーラップ中吹き返しガス流量算出フローを用いて説明する。
ステップ３５では、図１０のステップ９で算出された排気ガスのガス定数ＲＥＸと、ステップ１０で算出された排気バルブ閉弁時の筒内温度ＴＥＶＣとに基づき、ガス流量算出式密度項ＭＲＳＯＬＤを次式により算出する。
【００４８】
ＭＲＳＯＬＤ＝ＳＱＲＴ｜１／（ＲＥＸ×ＴＥＶＣ）｜・・・（１０）
ここで、ＳＱＲＴは温度及びガス定数に関する係数である。なお、制御構成上、ガス流量算出式密度項ＭＲＳＯＬＤの算出が困難な場合は、予め、（１０）式の計算結果をマップとして記憶しておき、排気ガスガス定数ＲＥＸと筒内温度ＴＥＶＣとに応じて求めてもよい。
【００４９】
ステップ３６では、図１１のステップ１６で算出された排気ガス比熱比ＳＨＥＡＴＲと、図１２のステップ２６で算出された吸気排気圧力比ＰＩＮＢＹＥＸとに基づき、ガス流量算出式圧力差項ＭＲＳＯＬＰを次式により算出する。
ＭＲＳＯＬＰ＝ＳＱＲＴ［ＳＨＥＡＴＲ／（ＳＨＥＡＴＲ－１）×｜ＰＩＮＢＹＥＸ＾（２／ＳＨＥＡＴＲ）－ＰＩＮＢＹＥＸ＾（（ＳＨＥＡＴＲ＋１）／ＳＨＥＡＴＲ）｝］・・・（１１）
ステップ３７では、図１０のステップ１１で算出された排気バルブ閉弁時筒内圧力ＰＥＶＣと、図１３のステップ３５とステップ３６とで算出されたガス流量算出式密度項ＭＲＳＯＬＤとガス流量算出式圧力差項ＭＲＳＯＬＰとに基づいて、過給無し・チョーク無し時のオーバーラップ中の吹き返し流量ＭＲＥＳＯＬｔｍｐを次式により算出する。
【００５０】
ＭＲＥＳＯＬｔｍｐ＝１．４×ＰＥＶＣ×ＭＲＳＯＬＤ×ＭＲＳＯＬＰ・・・（１２）
また、ステップ２１の吹き返しガス流量ＭＲＥＳＯＬｔｍｐについて、図１４の過給無し且つチョーク有り時の吹き返しガス流量算出フローを用いて説明する。
【００５１】
ステップ３８では、図１３のステップ３５と同じく、ガス流量算出式密度項ＭＲＳＯＬＤを前述の（１０）式より算出する。
ステップ３９では、図１１のステップ１６で算出された排気ガス比熱比ＳＨＥＡＴＲに基づき、ガス流量算出式チョーク時圧力差項ＭＲＳＯＬＰＣを次式により求める。

【００５２】
ＭＲＳＯＬＰＣ＝ＳＱＲＴ［ＳＨＥＡＴＲ×｛２／（ＳＨＥＡＴＲ＋１）｝＾｛（ＳＨＥＡＴＲ＋１）／（ＳＨＥＡＴＲ－１）｝］・・・（１３）
なお、制御構成上、累乗計算が困難な場合には、予め（１３）式の計算結果を、ガス流量算出式チョーク時圧力差項ＭＲＳＯＬＰＣマップとして記憶しておき、排気ガス比熱比ＳＨＥＡＴＲに応じて求めてもよい。
【００５３】
ステップ４０では、図１０のステップ１１で算出された排気バルブ閉弁時筒内圧力ＰＥＶＣと、図１４のステップ３８で算出されたガス流量算出式密度項ＭＲＳＯＬＤと、ステップ３９で算出されたチョーク時圧力差項ＭＲＳＯＬＰＣに基づいて、過給無し・チョーク有り時のオーバーラップ中吹き返し流量ＭＲＥＳＯＬｔｍｐを次式により算出する。
【００５４】
ＭＲＥＳＯＬｔｍｐ＝ＰＥＶＣ×ＭＲＳＯＬＤ×ＭＲＳＯＬＰＣ・・・（１４）
また、ステップ２３のオーバーラップ中の平均吹き返しガス流量ＭＲＥＳＯＬｔｍｐの算出について、図１５の過給有り・チョーク無し時の吹き返しガス流量算出フローを用いて説明する。
【００５５】
ステップ４１では、図１２のステップ３０で算出された排気ガス比熱比ＳＨＥＡＴＲと、ステップ２６で算出された吸気排気圧力比ＰＩＮＢＹＥＸとに基づき、ガス流量算出式過給時圧力差項ＭＲＳＯＬＰＴを次式により求める。
ＭＲＳＯＬＰＴ＝ＳＱＲＴ［ＳＨＥＡＴＲ／（ＳＨＥＡＴＲ－１）×｛ＰＩＮＢＹＥＸ＾（－２／ＳＨＥＡＴＲ）－ＰＩＮＢＹＥＸ＾（－（ＳＨＥＡＴＲ＋１）／ＳＨＥＡＴＲ）｝］・・・（１５）
なお、制御の構成上、累乗計算が困難な場合は、予め（１５）式の計算結果を、ガス流量算出式過給時圧力差項ＭＲＳＯＬＰＴマップとして記憶しておき、排気ガス比熱比ＳＨＥＡＴＲと吸気排気圧力比ＰＩＮＢＹＥＸとに応じて求めてもよい。
【００５６】
ステップ４２では、吸気圧力センサ１０の信号に基づいて検出された吸気圧力ＰＩＮと、ステップ４１で算出された過給時圧力差項ＭＲＳＯＬＰＴとに基づいて、過給有り・チョーク無し時オーバーラップ中吹き返しガス流量ＭＲＥＳＯＬｔｍｐを次式により算出する。
ＭＲＥＳＯＬｔｍｐ＝－０．１５２×ＰＩＮ×ＭＲＳＯＬＰＴ・・・（１６）
ここで、吹き返しガス流量ＭＲＥＳＯＬｔｍｐは負の値を示すことで、オーバーラップ中に吸気系から排気系へ吹き抜けるガス流量を表すことができ、これに基づいて内部ＥＧＲ量を減じる。
【００５７】
また、ステップ２４の吹き返しガス流量ＭＲＥＳＯＬｔｍｐの算出について、図１６の過給有り・チョーク有り時オーバーラップ中吹き返しガス流量算出フローを用いて説明する。
ステップ４３では、図１４のステップ３９と同じく、ガス流量算出式チョーク時圧力差項ＭＲＳＯＬＰＣを（１３）式またはマップから求める。
【００５８】
ステップ４４では、吸気圧力ＰＩＮと、ガス流量算出式チョーク時圧力差項ＭＲＳＯＬＰＣとに基づいて、過給有り・チョーク有り時のオーバーラップ中吹き返しガス流量ＭＲＥＳＯＬｔｍｐを次式により算出する。
ＭＲＥＳＯＬｔｍｐ＝－０．１０８×ＰＩＮ×ＭＲＳＯＬＰＣ・・・（１７）
ここで、吹き返しガス流量ＭＲＥＳＯＬｔｍｐは負の値を示すことで、オーバーラップ中に吸気側から排気側へ吹き抜けるガス流量を表すことができ、内部ＥＧＲ量を減じることとなる。
【００５９】

ここで、ステップ２０，２１，２３，２４で、過給の有無とチョークの有無との状態に応じて、吹き返しガス流量ＭＲＥＳＯＬｔｍｐを算出する。そして、前述のステップ２５でオーバーラップ中吹き返しガス量ＭＲＥＳＯＬを算出した後は、図９のステップ６からステップ７へ進み、前述のステップ７で内部ＥＧＲ量ＭＲＥＳを算出する。そして、図８のステップ３からステップ４へ進み、前述の内部ＥＧＲ率ＭＲＥＳＦＲを算出して、処理を終了する。

【００６０】

本実施形態によれば、排気バルブ閉弁時の筒内温度ＴＥＶＣを算出する手段（ステップ１０）と、排気バルブ閉弁時の筒内圧力ＰＥＶＣを算出する手段（ステップ１１）と、燃焼空燃比に応じた排気ガス組成のガス定数ＲＥＸを算出する手段（ステップ９）と、少なくとも前記筒内温度ＴＥＶＣ、前記筒内圧力ＰＥＶＣ、前記ガス定数ＲＥＸに基づいて、排気バルブ閉弁時の筒内ガス量ＭＲＥＳＣＹＬを算出する手段（ステップ１２）と、排気バルブ開期間と吸気バルブ開期間とのオーバーラップ中の吹き返しガス量ＭＲＥＳＯＬを算出する手段（ステップ２５）と、を備え、筒内ガス量ＭＲＥＳＣＹＬと吹き返しガス量ＭＲＥＳＯＬとに基づいて、内部ＥＧＲ量ＭＲＥＳを算出する（ステップ７）。このため、燃焼終了後のシリンダ内部の状態量（温度ＴＥＶＣ・圧力ＰＥＶＣ・ガス定数ＲＥＸ）に基づき、物理式から内部ＥＧＲ量ＭＲＥＳを算出できる。そして、温度・圧力変化による密度変化や、燃焼空燃比変化に伴うガス定数の変化による密度変化に対応でき、運転条件に関わらず精度良く内部ＥＧＲ量ＭＲＥＳを推定できる。特に、過渡運転状態においては、シリンダ内部の状態量が刻々と変化するため、その変化していく状態量に基づいて内部ＥＧＲ量ＭＲＥＳを算出できるので、過渡運転時の内部ＥＧＲ量ＭＲＥＳの推定精度を向上できる。そして、内部ＥＧＲ量ＭＲＥＳを精度良く推定することで、点火時期、燃料噴射量、バルブ開閉タイミング（オーバーラップ量）などを適切に制御できる。さらに、多次元パラメータを含む制御構築であっても、各パラメータに応じ、物理式（３式）に基づいて内部ＥＧＲ量ＭＲＥＳを算出し、この値ＭＲＥＳに基づいて、各制御値を決定するため、容易に構築できる。

【００６１】

また本実施形態によれば、さらに排気バルブ閉弁時の筒内容積ＶＥＶＣを算出する手段（ステップ８）を含んで構成され、これらの算出値に基づいて、物理式（４式）により排気バルブ閉弁時の筒内ガス量ＭＲＥＳＣＹＬを算出する。このため、排気バルブ閉弁時の筒内容積ＶＥＶＣを考慮して、燃焼終了後のシリンダ内部の状態量（容積ＶＥＶＣ・温度ＴＥＶＣ・圧力ＰＥＶＣ・ガス定数ＲＥＸ）に基づき、物理式（３式）から内部ＥＧＲ量ＭＲＥＳを算出できる。この場合も、温度・圧力変化による密度変化や、燃焼空燃比変化に伴うガス定数の変化による密度変化に対応でき、運転条件に関わらず精度良く内部ＥＧＲ量ＭＲＥＳを推定できる。また、多次元パラメータを含む制御構築であっても、各パラメータに応じ、物理式（３式）に基づいて内部ＥＧＲ量ＭＲＥＳを算出するため、容易に構築でき、適合が容易となる。

【００６２】

また本実施形態によれば、排気バルブ閉弁時筒内容積算出手段（ステップ８）は、排気バルブ閉弁時のピストン位置から幾何学的に決まる筒内容積値ＶＥＶＣを求める。このため、排気バルブ閉弁時の筒内容積ＶＥＶＣを適切に算出して、より正確な内部ＥＧＲ量ＭＲＥＳを求めることができる。

また本実施形態によれば、排気バルブ閉弁時筒内容積算出手段（ステップ８）は、排気バルブ閉弁時期と該時期の筒内容積とを相対的に変化させる機構を有するエンジンにおいては、その変化量に応じて、排気バルブ閉弁時の筒内容積値ＶＥＶＣを求める。このため、排気バルブ閉弁時に筒内容積ＶＥＶＣが変化する機構（可変バルブ開閉タイミング、可変圧縮比）を有するエンジンであっても、容易に筒内容積ＶＥＶＣを求められ、より正確な内部ＥＧＲ量ＭＲＥＳを算出できる。そして、各値は幾何学的に決まるので、容易に算出でき、実機運転による適合させる必要が無くなり、開発が効率的に行える。

【００６３】

また本実施形態によれば、ガス定数算出手段（ステップ９）は、目標燃焼当量比ＴＦＢＹＡに応じ、排気ガス組成の変化に対応するガス定数ＲＥＸを求める（図１８）。このため、目標燃焼当量比ＴＦＢＹＡに応じた排気ガス組成変化に伴う密度変化がある場合、すなわち、リーン運転、始動後、全開運転域への切り替え後における目標燃焼当量比ＴＦＢＹＡの増減がある場合にも、内部ＥＧＲ量ＭＲＥＳを精度良く推定できる。そして、ガス定数ＲＥＸは、燃料組成と空気組成とによる化学反応式から算出でき、実機運転による適合させる必要が無くなり、開発が効率的に行える。

【００６４】

また本実施形態によれば、オーバーラップ中吹き返しガス量算出手段（ステップ２５）は、排気バルブ閉弁時の筒内温度ＴＥＶＣを算出する手段（ステップ１０）と、排気バルブ閉弁時の筒内圧力ＰＥＶＣを算出する手段（ステップ１１）と、燃焼空燃比に応じた排気ガス組成変化に対応したガス定数ＲＥＸを算出する手段（ステップ９）と、吸気圧力ＰＩＮを算出する手段（ステップ１０）と、排気ガス組成変化に対応した比熱比ＳＨＥＡＴＲを算出する手段（ステップ１４）と、排気バルブ開期間と吸気バルブ開期間とのオーバーラップ中の積算有効面積ＡＳＵＭＯＬを算出する手段（ステップ１４）と、機関回転数ＮＲＰＭを算出する手段（ステップ１５）と、過給及びチョークの有無を判定する手段（ステップ２７，３２）と、を含んで構成され、これらの算出値に基づいて、オーバーラップ中の吹き返しガス量ＭＲＥＳＯＬを算出する。このため、オーバーラップ中の状態量（温度ＴＥＶＣ、圧力ＰＥＶＣ、ガス定数ＲＥＸ、面積ＡＳＵＭＯＬ）に基づき、物理式（７式）により吹き返しガス量ＭＲＥＳＯＬを精度良く算出できる。そして、状態量の変化による密度変化やオリフィス通過体積流量変化に対応でき、あらゆる運転状態において精度良くオーバーラップ中吹き返しガス量ＭＲＥＳＯＬを算出できる。さらに、多次元パラメータを含む制御構築においても、各パラメータに応じて物理式（３式）に基づき内部ＥＧＲ量ＭＲＥＳを算出するため、容易に構築でき、適合が容易となる。

【００６５】

また本実施形態によれば、過給及びチョークの判定手段（ステップ２７，３２）は、吸気圧力ＰＩＮと排気バルブ閉弁時筒内圧力ＰＥＶＣとに基づいて、吸気排気圧力比ＰＩＮＢＹＥＸを算出する手段（ステップ２６）を備え、排気ガス組成変化に対応した比熱比ＳＨＥＡＴＲを、過給判定手段（ステップ２７）が過給有りとした場合に設定する。このため、全開運転における慣性過給時や、過給機による過給時でも精度良くオーバーラップ中の吹き返しガス量ＭＲＥＳＯＬを算出できる。そして、アイドル運転時などにおいてチョークが発生した場合でも精度良く吹き返しガス量ＭＲＥＳＯＬを算出できる。

【００６６】

また本実施形態によれば、オーバーラップ中積算有効面積算出手段（ステップ１４）は、吸気バルブ開閉タイミングを算出する手段（図２０）と、排気バルブ開閉タイミングを算出する手段（図２０）と、からオーバーラップ量を算出し、このオーバーラップ量に応じて積算有効面積ＡＳＵＭＯＬを求める。このため、オーバーラップ量に基づいて積算有効面積ＡＳＵＭＯＬを算出でき、物理式（６式）による計算を簡略化することができる。

【００６７】

また本実施形態によれば、オーバーラップ中積算有効面積算出手段（ステップ１４）は、吸気バルブリフト中の開口面積と排気バルブリフト中の開口面積とのいずれか一方の最小値を積分し、積算有効面積ＡＳＵＭＯＬを算出する。このため、オーバーラップ期間の積算有効面積ＡＳＵＭＯＬを１つのオリフィスとして疑似でき、排気系の状態と吸気系の状態とからこのオリフィスを通過する流量を簡略的に算出することができる。

【図面の簡単な説明】

【図１】内部ＥＧＲ量推定装置のシステム構成図

【図２】内部ＥＧＲ率算出手段の制御構成図

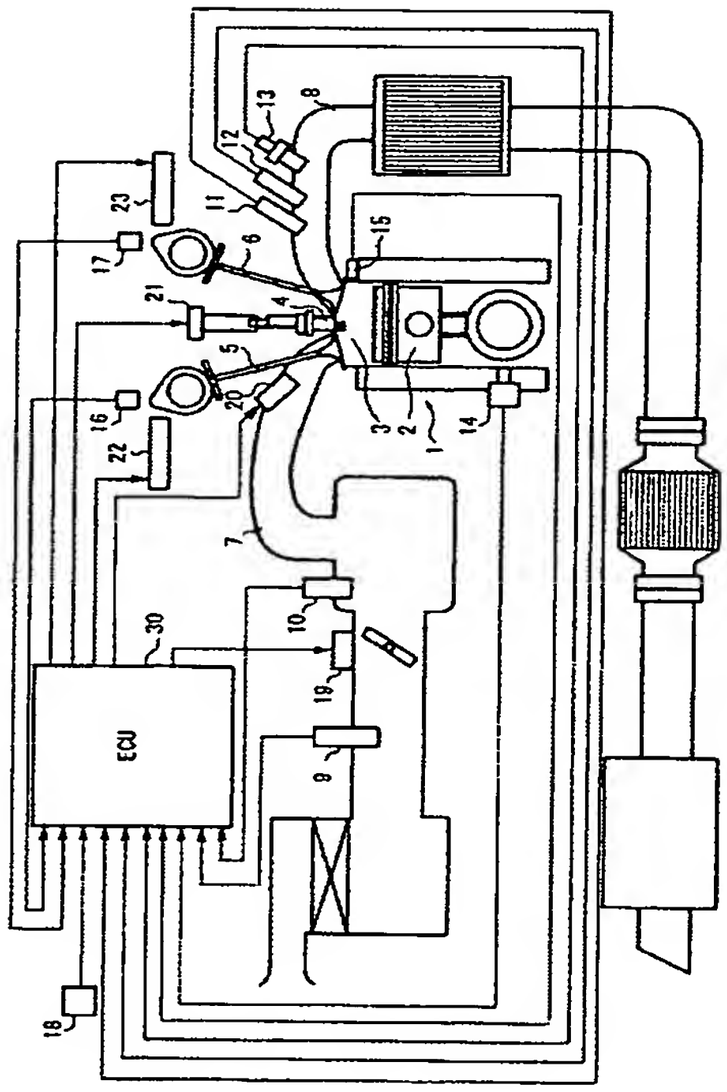
【図３】内部ＥＧＲ量算出手段の制御構成図

【図４】排気バルブ閉弁時筒内ガス流量算出手段の制御構成図

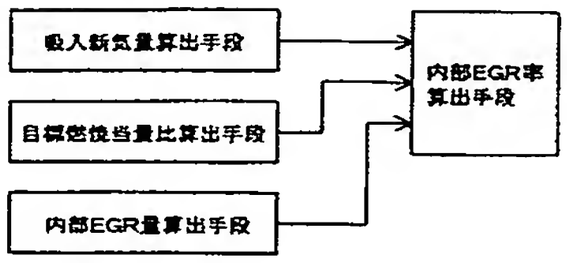
【図５】オーバーラップ中吹き返しガス量算出手段の制御構成図

【図６】排気ガス比熱比算出手段の制御構成図
【図７】過給・チョーク判定手段の制御構成図
【図８】内部ＥＧＲ率算出フローチャート
【図９】内部ＥＧＲ量算出フローチャート
【図１０】排気バルブ閉弁時筒内ガス量算出フローチャート
【図１１】オーバーラップ中吹き返しガス量算出フローチャート
【図１２】過給判定・チョーク判定フローチャート
【図１３】過給無し・チョーク無し時オーバーラップ中吹き返しガス流量算出フローチャート
【図１４】過給無し・チョーク有り時オーバーラップ中吹き返しガス流量算出フローチャート
【図１５】過給有り・チョーク無し時オーバーラップ中吹き返しガス流量算出フローチャート
【図１６】過給有り・チョーク有り時オーバーラップ中吹き返しガス流量算出フローチャート
【図１７】排気バルブ閉弁時筒内容積算出テーブル
【図１８】排気ガスガス定数算出テーブル
【図１９】オーバーラップ中積算有効面積算出テーブル
【図２０】オーバーラップ中積算有効面積の説明図
【図２１】排気ガス比熱比算出テーブル
【図２２】混合気比熱比算出テーブル
【符号の説明】
１　エンジン
５　吸気バルブ
６　排気バルブ
１０　吸気圧力センサ
１１　排気圧力センサ
１２　排気温度センサ
１３　Ｏ２センサ
１４　クランク角センサ
１５　水温センサ
１６　吸気側カム角センサ
１７　排気側カム角センサ
１８　アクセル開度センサ
３０　ＥＣＵ

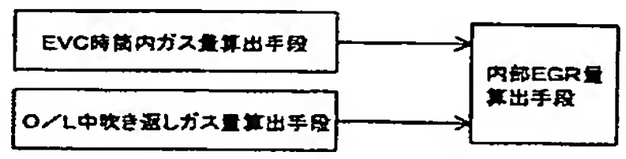
【図１】



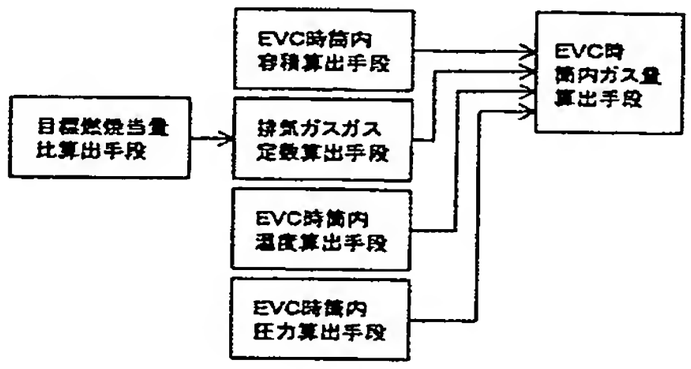
【図２】



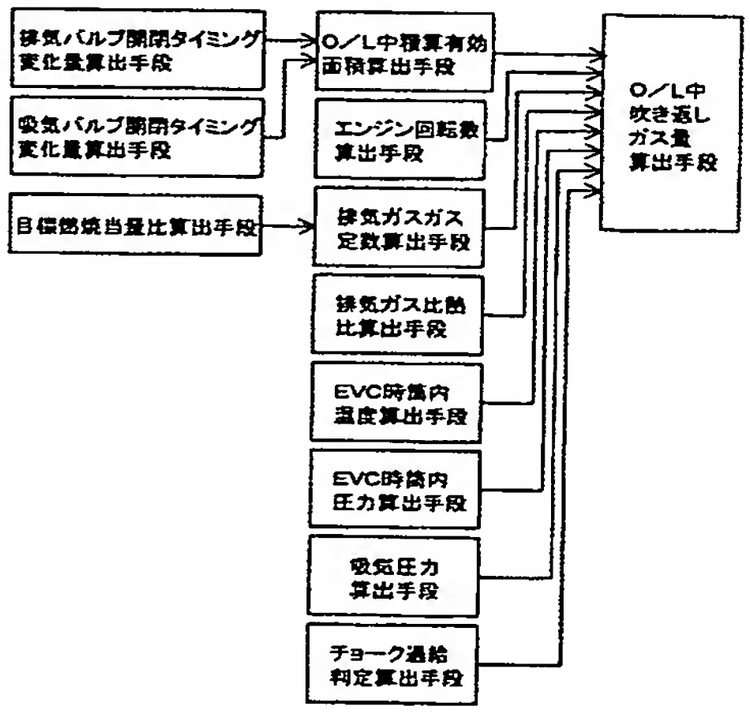
【図３】



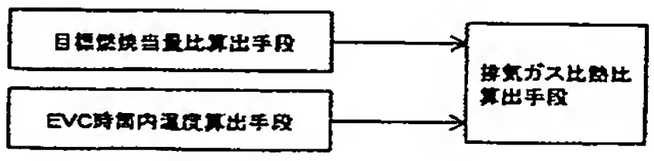
【図４】



【図５】



【図６】



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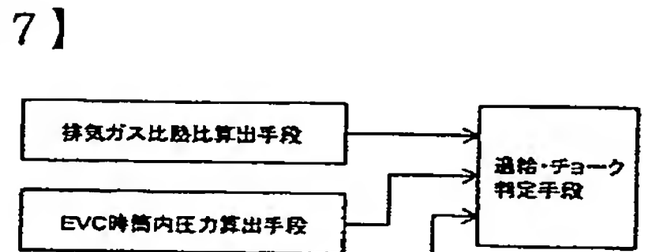

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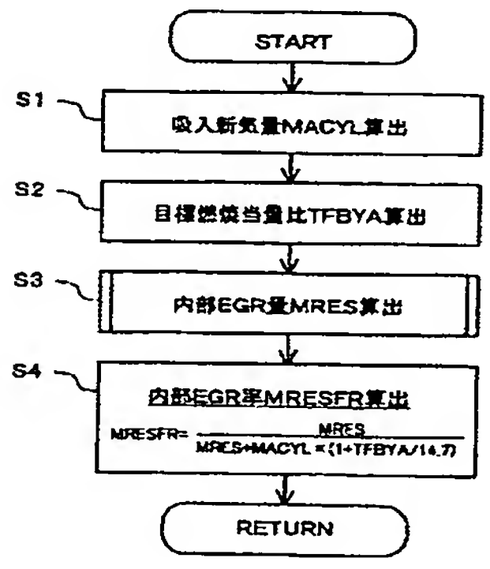

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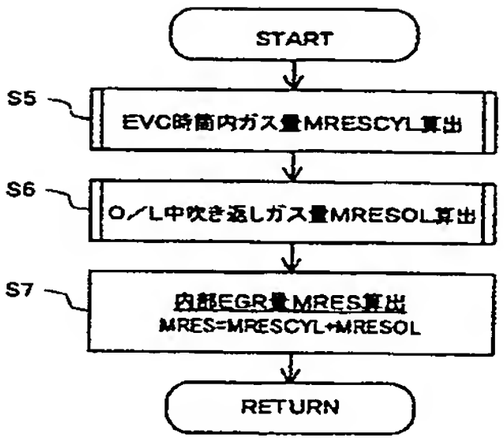

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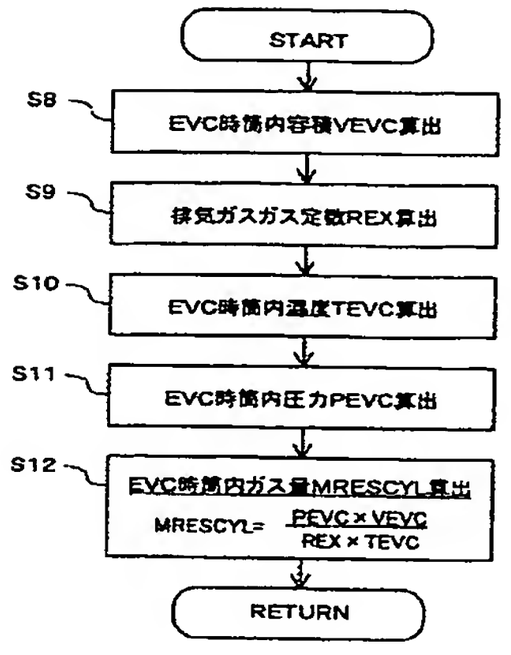

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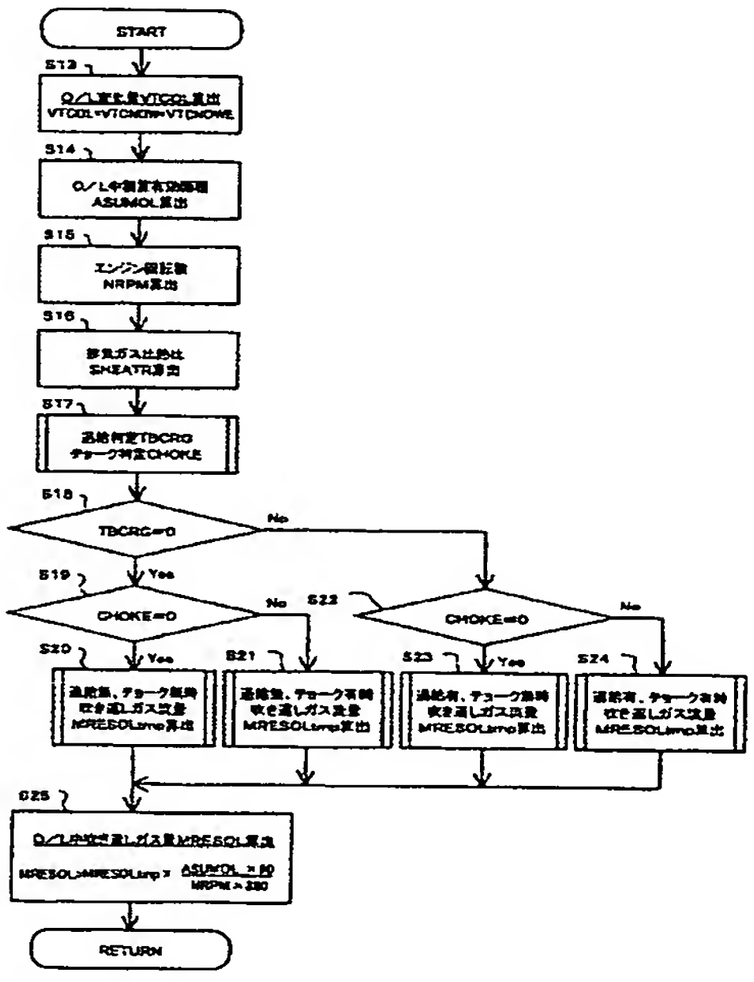

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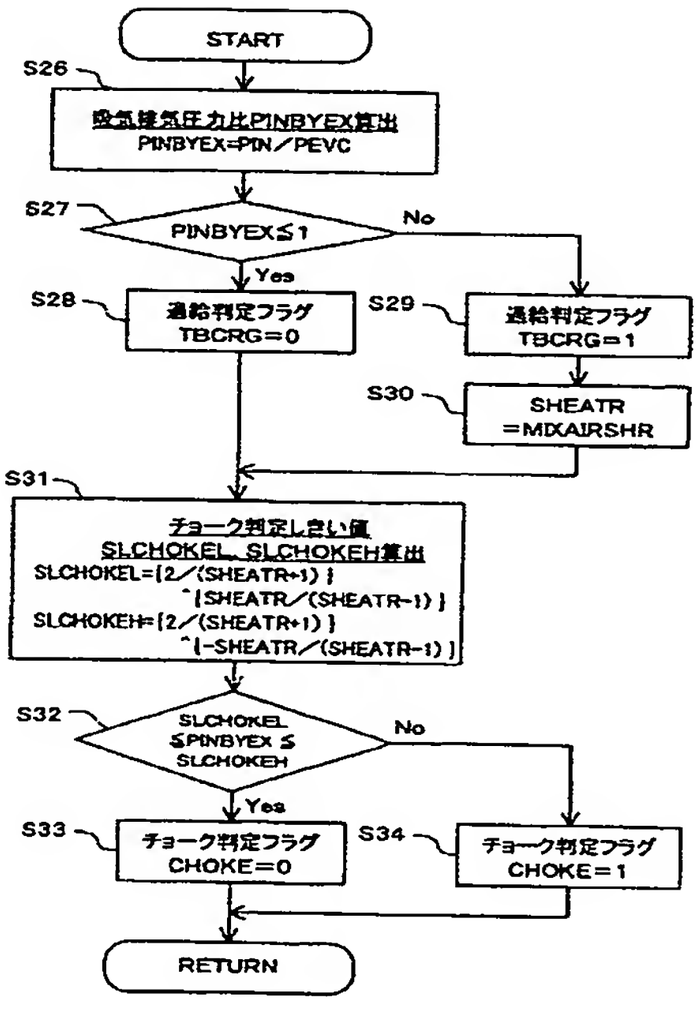

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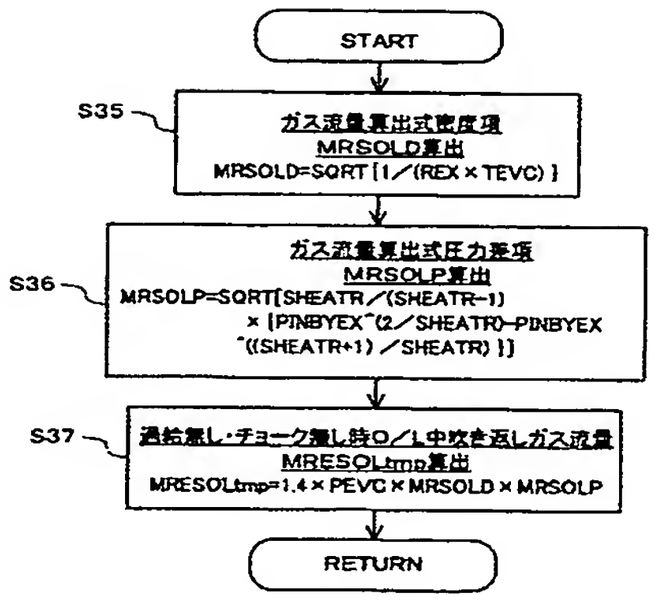

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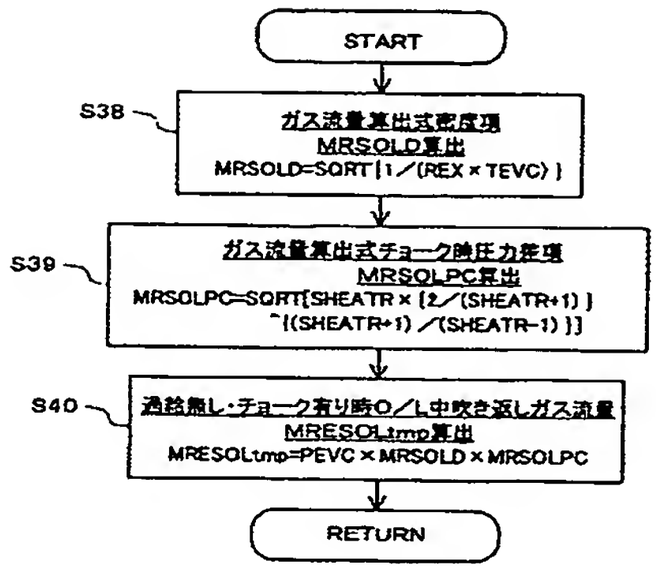

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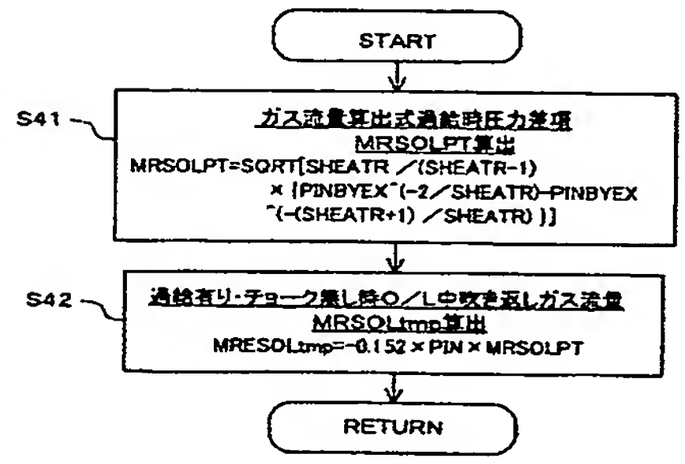

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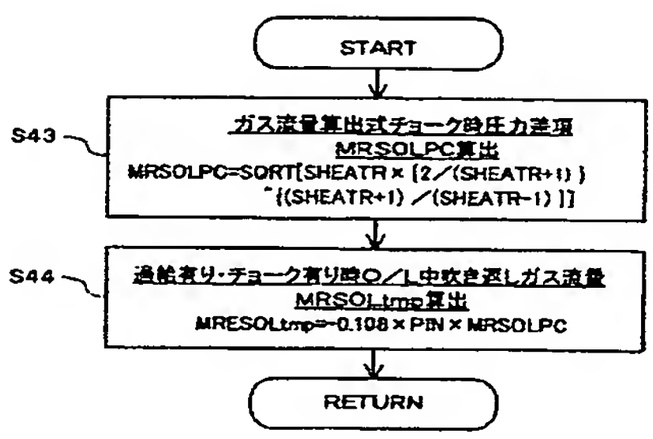

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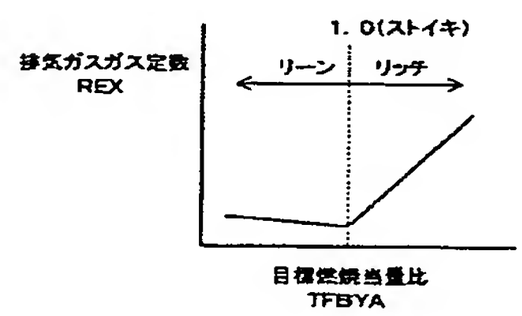

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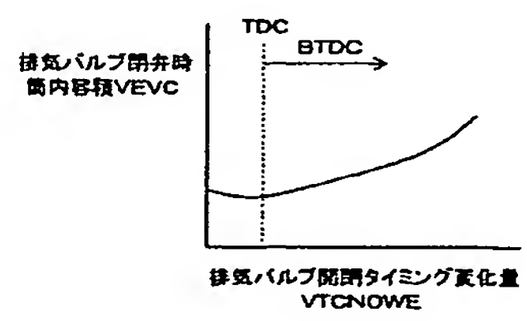

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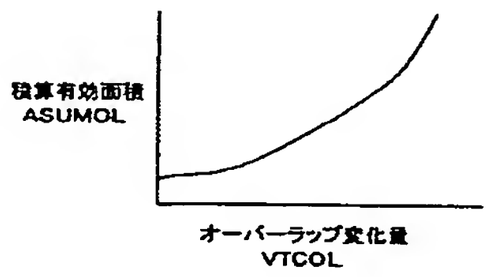

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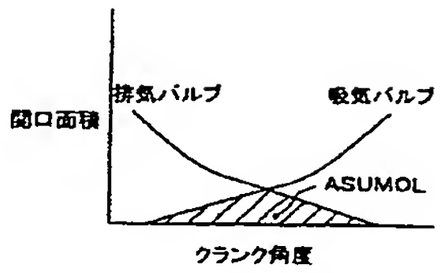
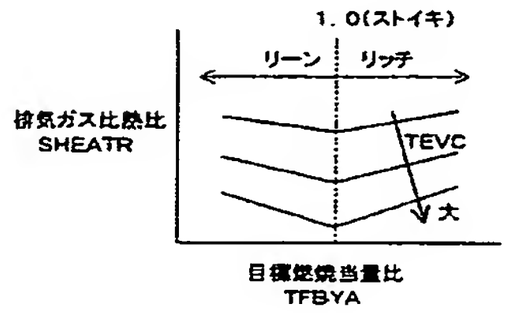
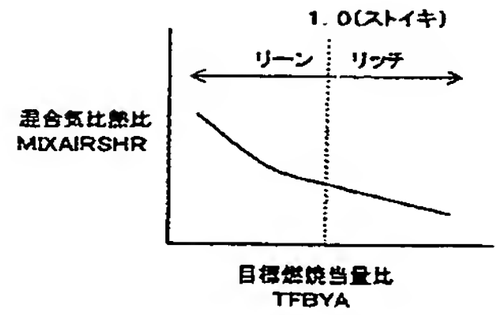

排気バルブ
吸気バルブ
開口面積
ASUMOL
クランク角度

【図２１】


1．0(ストイキ)
リーン
リッチ
排気ガス比熱比
SHEATR
TEVC
大
目標燃焼当量比
TFBYA

【図２２】


1．0(ストイキ)
リーン
リッチ
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MIXAIRSHR
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TFBYA

フロントページの続き

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